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THE IMPERIAL ECONOMIC COMMITTEE.

OUR attention has recently been drawn to the work of the Imperial Economic Committee by the publication of its Progress Report* for 1930. This Committee is purely an advisory body which was appointed as a result of resolutions passed at the Imperial Economic Conference and also at the Imperial Conference in 1926 when its work was endorsed and its operations extended. The Committee, which is responsible for its activities to all the Governments of the Empire, has for the past five years been principally concerned in studying the possibilities of stimulating Empire trade. In this connection it has carried out valuable investigations in the marketing of Empire products, conducted enquiries into raw materials and prepared a number of preliminary trade surveys.

The first Report of the Committee laid down the foundations of the voluntary preference movement and suggested that inter-Empire co-operation in agricultural research should be put on a broader basis. The Committee early recognised that the policy of voluntary preference could only be successful if the consumer was taught to distinguish Empire goods from foreign goods, and was made to appreciate the economic advantages of buying within the Empire. The Empire producer would on the other hand have to realise that his products should at least equal those of his foreign competitors in quality, quantity and continuity of supply. As the Committee had no executive powers it recommended that the inauguration of the voluntary preference movement and the organisation of research should be entrusted to an executive body. The result of this recommendation was the setting up in 1926 of the Empire Marketing Board which has relied, to a great extent, on the results of the Imperial Economic Committee's investigations before proceeding itself to examine the needs of various forms of Empire production.

Although the doctrine of voluntary preference has quickened and interest in the Empire become more defined, much yet remains to be done before the fundamental economic argument underlying the movement becomes really the actuating motive of the great body of consumers. There are few signs, as yet, states the Committee,

*Reports of the Imperial Economic Committee. Seventeenth Report. Progress Report—1930. price (6d.) H.M.S.O., London.

that the wholesalers have changed their sources of supply to meet the growing consciousness on the part of the public. It is, however, fair to recognise that apart from pressure from the ultimate consumers, the trader, *qua* trader, has no strong economic motive for breaking away from his old connections. It is for the producer to contribute to this economic motive and the Committee, in its Reports, has repeatedly called attention to the necessity in different trades for improvement by producers in their technique of production and in the organisation of their selling. The large sum of money which is now being spent in creating a new habit of mind among consumers carries with it also obligations on producers to produce foodstuffs of the right quantity, of the right quality, and of the right price.

The Reports of the Committee—18 in number—have dealt with general subjects (*e.g.*, the policy of voluntary preference); food products (meat, fruit, dairy produce, poultry and honey, pigs and pig products, tobacco and tea); raw materials (timber, hides and skins); and trade surveys (agricultural machinery and rubber manufactured goods). These Reports which have been addressed in some cases to the growers and in others to the distributors, have sought to bring out the dominant facts of the competition between foreign and Empire producers. For instance, the Report on fruit revealed on one hand that a monopoly in foreign hands had practically been established in the supply, especially of certain tropical and sub-tropical fruits, to the United Kingdom and that there was some danger of a rationing with a view to the maintenance of prices. On the other hand, there were certain other fruits, produced in foreign countries with vast home markets, of which the surplus crops in productive years could be thrown into the United Kingdom market with disastrous effects on the stable production of those fruits within the Empire. As an outcome of the Committee's recommendations on bananas a direct service of steamers was established between Jamaica and England. A strong point was also made of the careless packing and unattractive presentation of many lines of Empire produce, as compared with similar foreign products. In the case of tobacco, a new problem presented itself, that of adjusting the amount of production in overseas parts of the Empire to the gradual growth of the market in the united Kingdom. Losses had followed in a too rapid increase in the production of a tobacco for which the taste of the consumers in the United Kingdom had not been prepared, although the possibility of a gradual education of that taste had been made very evident in recent years by the transfer of custom from Oriental to Virginian tobacco. The trade survey on agricultural machinery showed that for the purpose of export the amalgamation of small concerns into powerful corporations is, under modern conditions, essential. With regard to rubber goods it was found that the manufacture of tyres was in the hands of seven vast organisations which although international in the scope of their activities, competed with each other throughout the world. In the case of this trade, official statistics of imports supplied by different Governments cease to have much significance unless interpreted by a knowledge, difficult to obtain, of the policies of the different corporations in their competition with one another. A sudden rise or fall in imports or exports in a given country may denote no more than the opening or closing down of a single great factory. Enquiries of special interest to the tropical producers which have not yet been completed, include coffee, cocoa and sugar.

The Committee calls attention to three suggestions of a general nature emerging from its enquiries. In the first place it is of the opinion that Empire producers require information as to what is taking place in their several trades. Early intimation of some of this information such as seasonal crop prospects, movement of crops, changes in marketing methods, tariffs, export or import regulations, is needed. Producers, contemplating investment of capital in new developments will also require information which will give them an idea of the future demand for the product they propose to cultivate. To satisfy this need the Committee has suggested the formation of an Intelligence Service organised trade by trade. In the second place it expresses the opinion that the creation and assimilation of Empire standards in regard to many trades, both of primary production and manufacture, should greatly simplify the promotion of Inter-Imperial trade. Lastly it hopes that under the lead of the Economic Organisation of the League of Nations, further steps may be taken to secure that trade statistics compiled by the various Governments of the world be based on such common rules as will render them more truly comparable.

It will be seen from this brief reference to the Imperial Economic Committee's work that it is carrying out many investigations which have a direct bearing on agricultural industries in the tropics. For a more careful study of its activities in that direction the tropical producer is referred to the reports which it has already issued on fruit, tobacco, rubber and tea, and to the subsequent reports that will shortly appear on coffee, cocoa and sugar. In conclusion we would like to welcome the Committee's suggestion for the formation of an Intelligence Service. The need for such a Service is really urgent and if organised on proper lines, should prove of much benefit to agricultural producers in all parts of the Empire.

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BANANA STORAGE.

The Behaviour and Diseases of the Banana in Storage and Transport with Special Reference to Chilling.

Précis of a Report submitted to the Empire Marketing Board.

By Claude W. Wardlaw, *Pathologist*, and Laurence P. McGuire, *Physiologist, Low Temperature Station.*

[*In a previous Report we recommended rapid cooling as an important preventive measure in the control of banana diseases, and in view of the impression current in the Trade that chill effects would result from such a procedure, further detailed investigation seemed imperative. We have been able to confirm our previous recommendations and at the same time to define more accurately the nature and limits of chilling.*]

I—Retrospect.

Researches at the Low Temperature Station, Imperial College of Tropical Agriculture, Trinidad, B.W.I., are directed chiefly to the major problems of the Banana Industry, namely, the need for a substitute for the Gros Michel, and the prevention of wastage in cargoes.

In an earlier communication, (1) attention was drawn to the promising possibility of the Cavendish (Trinidad Governor) as a substitute, while by correlating temperature and fungal growth it was advocated, *inter alia*, that the interval between reaping and commencement of refrigeration be shortened to the utmost and that the cargo be cooled to 53° F. as expeditiously as possible, by delivering air at that temperature.

While main-stalk rot is a considerable source of wastage in banana cargoes, another important source of depreciation is "chilling," through fear of which the Trade has for many years been prejudiced against rapid cooling. Our research then, of which the following is an account, was directed to determining the limits of chilling.

II—What is Chilling?

Chilling is an unhealthy condition induced by exposure during storage and transport to unsuitably low temperatures, and in this respect is not unlike the premature physiological breakdown of Bramley seedling apples stored at temperatures below 36° F. It is perhaps difficult to recognise externally in green bananas, though it has previously been identified in a general way by an increased development of brown streaks in the sub-epidermal tissues (2). A more detailed microscopic examination shows this characteristic colouration to be associated with the mucilage ducts.

During ripening, chilling is easily recognised by several abnormalities:—

(i) Delayed ripening (and in bad cases complete failure to ripen).

(ii) The hardening of the central placenta—more pronounced in the Cavendish than in the Gros Michel.

(iii) The assumption of a dull yellow colour instead of a healthy bright one.

(iv) In the Gros Michel as ripening proceeds, the dull yellow is replaced entirely by a dull russet colour which later darkens and is rendered more unsightly by the presence of black blotches and patches which are soft to the feel. Sometimes the fruit shows a characteristic dark brown mottling, apparently associated with desiccation of tissues. In places one finds large sunken patches, and on cutting open, the tissue is found to be entirely broken down. It should be noted, however, that this russetting of the whole bunch has not been noticed in the Cavendish even when kept for 50 days at 52° F. (*vide* senescence studies later). In point of fact, up to the present we have found it difficult to recognise chilling in this variety, as fruit picked at an immature stage shows, on ripening hardness of centres, dullness of colour, and a tendency to browning (not typical Gros Michel russetting)—characteristics which at an earlier stage had been tentatively regarded as chill effects. When definite chilling was established in the Cavendish, it was readily recognised during ripening at 70° F. by the assumption of a dull, sooty, ashen colour.

(v) In both varieties, the complete loss of banana flavour or the presence of a strange "cold storage flavour."

(vi) *a.* "Green-ripeness." } These are referred
b. "Hard-ripeness." } to later.

While the intensity and extent of russetting in the Gros Michel and of the ashen-grey colour observed in the Cavendish seem an indication of the severity of chilling, the precise condition (or conditions) whether of maturity at harvesting or of pre-storage nutritional factors, which predisposes a bunch to one or other particular form of chilling has not so far been ascertained.

While chilling, except in severe cases, seldom causes total loss, the resultant poor-flavoured, unattractive product commands low prices in the market.

III—Senescence Studies.

In our storage studies in which we have endeavoured to repeat trade conditions, the fruit has usually been kept for a period of from 15 to 24 days in cold storage at 52° to 55° F. after which it was transferred to the ripening room at the higher temperature of 70° F. In the course of these senescence studies, however, a departure from the usual routine was made, in that the fruit was not transferred to the ripening room but left indefinitely at cold storage temperatures by way of determining (1) the retarding action of cold temperatures on the ripening enzyme (or enzymes), (2) the storage expectancy at those temperatures, and (3) the adverse effects, if any, of long storage at those temperatures.

These senescence studies may be summarised as follows:

(i) The studies conducted at 53° F., 52.5° F., and 52° F., respectively with fruit representing a gradation in maturity depict in an interesting way the length of storage life before the onset of senescence and decline for the different temperatures of storage.

(ii) As the cooling of the small consignments used was necessarily very rapid, they show in a striking way that the onset of chilling is a result of the cumulative effect of duration of exposure to the low temperature and (2) further show the numerous ways in which chilling, whether slight or serious, may manifest itself, and therefore provide excellent criteria for the chilling experiments described later.

(iii) They emphasise the importance of the time factor in wastage of fruit and main-stalks which have become contaminated with the various rot organisms. For the purpose of short storage of 14 to 17 days, temperatures in the neighbourhood of 52.5° F. have been sufficiently low to retard fungal growth so as to give no trouble in ripening and handling: in these longer trials, on the other hand, fungal growth was a decided factor in shortening the storage expectancy.

IV—Preliminary Rapid Cooling Tests.

In an earlier paper, we expressed the view that our comparative freedom from main-stalk rot was largely due to the rapidity with which we were able to cool down our smaller consignments—a practice against which the Trade, however, seems prejudiced through fear of chilling. It was felt, therefore, that precise information, defining the limits of chill and the duration of exposure inimical, was of primary practical importance. To these ends we have aimed at the more and more rapid cooling of consignments to progressively lower temperatures.

For the purposes of this summary a description of results is set forth in tabulated form below (Table I).

Table I.

	Bulk Trial No. 5	*Bulk Trial No. 6*	*Bulk Trial No. 7*
1. Temp. of store at completion of loading	62°F.	58°F.	56°F.
2. Temp. of store after fruit has been cooled down ..	52°F.	52°F.	52.5°F.
3. Time in hours before air temp. was 53°F.			
(*a*) delivery	2¼	1	1
(*b*) return	7½	7⅔	1½
4. Time in hours before air temp. was 52.5°F.			
(*a*) delivery	—	—	2⅙
(*b*) return	—	—	13½
5. Time in hours before air temp. was 52°F.			
(*a*) delivery	4	1¾	—
(*b*) return	14	12	—

Table I.—*Continued.*

	Bulk Trial No. 5.	*Bulk Trial No. 6.*	*Bulk Trial No. 7.*
6. Number of days in cold storage	10	14	24
7. Per cent. of "ship-ripes" ..	—	—	—
8. Per cent. of total rejects ..	—	—	—
9. Per cent. of attractive "ripes" by sixth day ..	27	50	89
10. Per cent. of attractive "ripes" by tenth day ..	100	96	98
11. Per cent. which failed to ripen	—	—	—
12. Per cent. chilled slightly ..	—	4	2

The following are the most important facts emerging from the above trials:—

(1) The slight chilling observed in Nos. 6 and 7 raises the question as to whether the cumulative effect of duration of exposure to the temperature of storage rather than the rapid cooling down to that temperature, is responsible, for the chill. For instance, after exposure of 24 days to 52.5° F. (No. 7) and of 14 days to 52° F. (No. 6), slight chilling effects were observed, but not so after ten days at 52° F. (No. 5) in which cooling was but slightly less rapid than in No. 6. It is significant that bunches of Gros Michel which were left at 52° F. for a further five days, making 15 days in all, showed characteristic chill effects. This will be discussed below in the next series of experiments.

(2) The chill effects were found in the Gros Michel only and not in the Cavendish, corroborating the results found in the senescence studies. It will be recalled in our earlier paper, that in Bulk Trials 3 and 4 of Cavendish, after quick cooling and exposure of 21 and 22 days respectively to 52° F., the fruit ripened normally and attractively.

(3) Quite apart from this advantage of cold resistance the Cavendish has stood ordinary Gros Michel un-crated conditions remarkably well. Vigorous bunches of good count consistently ripened attractively, indicating the importance of favourable pre-storage nutritional factors on the well-being in storage and subsequent ripening. It would be interesting indeed to study, in very much larger consignments, the storage behaviour of the Cavendish grown under uniform plantation conditions and intensive cultivation.

(4) While one must necessarily be guarded in defining the precise stage of maturity of a bunch of comparatively unknown pre-storage history, it seems safe to say that our experience has been, particularly in the case of Gros Michel, that after storage at 52° F. of 14 to 17 days, ripening has been perceptibly retarded. This would involve extra costs to the ripening consignees. It was thought that a simple modification might ensure the beneficial effects of quick cooling without the complication of slower ripening. Its merits were tested out in Bulk Trial No. 8, the details of which, for the purposes of clarity of description, are tabulated in (Table II).

Table II.

	Bulk Trial No. 8.
1. Temp. of store at completion of loading	64.6°F.
2. Temp. of store after fruit has been cooled down	52°F. for 4 days, then 53.6°F.
3. Time in hours before air temp. was 52°F.	
(*a*) delivery	3¼
(*b*) return	18
4. Number of days in cold storage ..	15
5. Per cent. of "ship-ripes" ..	Nil
6. Per cent. of "total rejects" ..	Nil
7. Per cent. of attractive "ripes" by sixth day	40
8. Per cent. of further attractive "ripes" by tenth day	90*
9. Per cent. which failed to ripen ..	Nil
10. Per cent. chilled	Nil

Several points call for further consideration.

(1) There was definitely no chill and ripening proceeded at normal rates.

(2) There was, however, a good deal of main-stalk rot. A consideration of the several possible contributing factors indicated that this was due to the rough treatment of the fruit by several new hands engaged in the loading operations.

Running parallel with this experiment, but not referred to in the table above, a number of bunches of both Gros Michel and Cavendish were stored at 53.6° F. from the commencement of the experiment and at intervals of 16, 20 and 24 days were removed to the ripening room. These bunches showed no abnormality of ripening; this fact will be made use of in the next experiment.

V—Detailed Chill Experiments.

The question of chill was studied in greater detail in the experiments which are now to be described.

Bulk Trial No. 9.

It has been shown that chilling effects have not been produced by:—

(i) Cooling to 52° F., no matter how rapidly, provided temperature of air delivery is not below 52° F.

(ii) Exposure of fruit to 52° F. for four days and then to 53.6° F. for 11 days.

(iii) Exposure of fruit to 53.6° F. for as long as 24 days. In the absence of a factor or factors unknown, it follows logically that, if fruit is attendant with characteristic chill effects after exposure to 52° F. for a period of X days (X days greater than four) and then to 53.6° F. for 24-X days, such chilling must be attributed to the exposure to 52° F. for X days.

Accordingly in this Bulk Trial, conducted at 52° F., three bunches of Cavendish and three of Gros Michel were removed each day and placed in a second storage chamber maintained at 53.6° F. for the remainder of the 24 days period. Each bunch had been carefully labelled and given a serial number and after transference to the ripening room, was examined at frequent intervals and observations noted.

The details of the experiment are tabulated below (Table III).

Table III.

1. Temp. of store at completion of loading	60°F.
2. Temp. of store after fruit has been cooled down	52°F. and 53.6°F. (*vide* text).
3. Time in hours before air temp. was 53°F.	
(*a*) delivery	3½
(*b*) return	8½
4. Time in hours before air temp. was 52°F.	
(*a*) delivery	4¾
(*b*) return	16½
5. Number of days in cold storage ..	24
6. Per cent. of "ship-ripes" ..	3 (just turning yellow).
7. Per cent. of total rejects	Nil
8. Per cent. of attractive "ripes" by sixth day	31
9. Per cent. of further attractive "ripes" by tenth day	29
10. Per cent. showing chill effects by sixth day	
(*a*) "green-ripes"	10
(*b*) "hard-ripe"	1
(*c*) dull or pasty coloured ..	7
(*d*) russet-coloured	2
Total	20
11. Per cent. showing chill effects by twelfth day	
(*a*) "green-ripe"	4
(*b*) "hard-ripe"	Nil
(*c*) dull or pasty coloured ..	7
(*d*) russet-coloured	2
Total	13
12. Per cent. showing further chill effects in their failure to ripen in seventeen days	4

It will be noted:—

(1) That the cooling was very rapid especially considering that this was a large consignment.

(2) The total percentage of bunches showing chill effects was 37 per cent., and this was manifested in several ways, *e.g.*: failure to ripen, or ripening to a dull, pasty or russet colour, "green-ripeness", and "hard-ripeness." The first named have been described under Senescence Studies, so our attention will be confined to the two mentioned last.

* This consignment was on the immature side, as evidenced by the low percentage of "ripes" by the sixth day, especially considering temperature of storage. The remainder ripened by the twelfth day.

"*Green-ripeness,*" as the name implies, is a condition in which the yellow colour is poorly developed, giving the impression of being but half ripe, while the edible portion is quite as soft as, or even softer than, a normally ripe and even over-ripe banana. This has been popularly attributed by the Trade (2) to too high a temperature of ripening during the summer time, but there is no doubt that a similar condition can be induced by chilling. For purposes of standardisation, our ripening throughout has been conducted at 70° F.

A less frequent chill effect is "*hard-ripeness*" in which as the name implies, the fruit is fully coloured (sometimes slightly dull) as in a ripe fruit, but the flesh is as firm as in a green fruit. The chill effect we have referred to above as "dull or pasty colour" is quite distinct from this, in that the flesh is as soft as in a normally ripened banana, and, except in severe cases, is quite palatable.

This experiment confirms our earlier findings, namely, that the duration of exposure to 52° F., inimical to the Gros Michel, is approximately 14 days, when slight chilling is evident. As this exposure is increased, chill effects become more pronounced until in the case of many bunches which had been kept at 52° F. for the whole period of storage (*i.e.*: 24 days) many showed obvious "green-ripening" and marked russetting.

While the great majority of Gros Michel, which were exposed for longer than 14 days to 52° F., showed chilling effects to varying degrees, nevertheless, many ripened attractively and as many as 13 per cent. of the bunches left for 24 days at 52° F., ripened to products of extremely pleasing appearance. *In every case these were vigorous bunches of high "count". This emphasises the view expressed earlier that favourable pre-storage factors play an important part in the well-being of the fruit in storage and in its resistance to cold.* This is an important observation and commends itself as a subject for more detailed study later.

Up to the present, the Governor has shown no definite chill effect at 52° F., despite the rapidity of cooling and the duration of exposure to that temperature.

Bulk Trial No. 10.

The behaviour of Gros Michel and Cavendish at 52° F., has proved comparatively consistent and it seems that our original recommendation of quick cooling to 53° F. allows of a considerable margin of safety, namely, 1° F. over a period of 14 days.

Bulk Trial No. 10 was to be conducted at 51° F., but unfortunately, owing to failure of the automatic electric thermostatic controls, temperatures fluctuated between 50° to 51° F. The experiment was continued so that the harmful effects, if any, might be observed. In making any recommendation to the Trade, it is realised that a margin of safety is essential.

By way of assessing more accurately the effects of the lower temperature the following procedure was adopted: each morning four comparable bunches of Gros Michel and of Cavendish were removed, divided into two representative consignments, and each bunch labelled and given a serial number. One lot was then stored at 53.6° F., while the other was transferred to the ripening room. Observations as to their behaviour were made at frequent intervals and compared. The details of the experiment are tabulated below (Table IV).

Table IV.

1. Temp. of store at completion of loading	64°F.
2. Temp. of store after fruit has been cooled down	50 to 51°F.
3. Time in hours before air temp. was 53°F.	
(*a*) delivery	4
(*b*) return	12¼
4. Time in hours before air temp. was 52°F.	
(*a*) delivery	4½
(*b*) return	16¼
5. Time in hours before air temp. was 51°F.	
(*a*) delivery	5¼
(*b*) return	24¼
6. Number of days in cold storage	24 (*vide* text)
7. Per cent. of "ship-ripes"	Nil
8. Per cent. of attractive "ripes"	34.5
9. Per cent. showing chill effects	
(*a*) "green-ripes"	8
(*b*) "hard-ripes"	4
(*c*) dull or pasty coloured	20
(*d*) russet-coloured	31
(*e*) failed to ripen	2.5
Total	65.5

For the first time we have induced chilling in the Trinidad Governor. In less severe cases the skin assumes a pasty dull colour and in more severe cases a brownish, sooty, ashen-grey, together with the almost complete loss of flavour. No russetting has so far been observed with this variety, but there has been an appreciable tendency to "hard-ripeness".

At the commencement of ripening, the consignment was characterised by comparative freedom from main-stalk rot, due, no doubt, to the low temperature of storage. In the comparatively slower rate of ripening subsequently in fruit which had been kept for most of the time at the lower temperature, main-stalk rot developed rapidly, and in many cases had already progressed into the cushion of the top hand before the fruit had ripened. On the grounds of (1) expenses to the jobber (2) the additional opportunities afforded to the rot organisms during the slower ripening and (3) the narrow margin of safety, a temperature of 51° F. for transport is not recommended.

Bulk Trial No. 11.

This storage trial with Gros Michel and Cavendish was again conducted at 51° F. in No. 3 chamber, and as before rapid cooling was aimed at. At commencement of loading the temperature of the storage air was 51° F.

The rate of cooling down was as follows :—

	Delivery.	*Return.*
53° F.	...After 4 hours	After 12½ hours.
52° F.	... do. 4½ do.	do. 17 do.
51° F.	... do. 7½ do.	do. 26 do.

After a return temperature of 51° F. had been obtained, four bunches of Gros Michel and four of Cavendish were labelled and removed daily for 24 days from No. 3 chamber and divided into two lots : the first was immediately hung up in No. 1 chamber at 70° F., developments during ripening being noted at frequent short intervals ("x" series), while the second lot ("y" series) was transferred to No. 4 chamber, held at 53.6 °F., for the remainder of the "voyage" period of 24 days, to be ripened subsequently.

In the "x" series the first occurrence of chill was noticed in fruit which had been subjected to nine days' exposure to 51° F. in the case of the Gros Michel and to 13 days' in the Cavendish variety. As the exposure increased the chill became more marked, all the chill effects mentioned above being in evidence. From the eighteenth day, it was really unnecessary to hang up the Gros Michel bunches as there was a predominant russetting throughout the consignment. In the Cavendish, however, chilling was not so readily recognisable at this stage, but after a few days in the ripening room was evident in the smoky ashen-grey colouration. The "y" series gave confirmatory results and further substantiated the view that exposure of as much as 24 days to 53.6° F. was not harmful to both varieties.

VI—Treatment of Main-Stalk Rot.

In all our storage trials, we have persisted with the vaseline treatment, and have found it efficacious, when properly applied. While the cut end is undoubtedly the main source of entry and protection at this point therefore advisable, it must be remembered that an easy entry for the rot organisms is also provided by breaks in the main-stalks, rupturing of the hand-cushions through careless handling, and skin punctures by animal agencies. In the ripening room, the cord by which the bunches are suspended causes a rupture of the stem, and provides an ingress for fungal organisms which progress upwards towards the vaselined end and downwards towards the first hand. Main-stalk rot has proved serious in the case of bunches which, through immaturity at harvesting or through chilling, ripened more slowly than normal.

As far as we have been able to ascertain, successful treatment of stems to prevent main-stalk rot must consist essentially of two operations.

I. The cutting off of a small portion of the stalk, whereby organisms which become associated with the stem end in the interval between reaping and loading are removed, and

II. A suitable means of preventing re-infection, such as vaseline, sterilised tallow, &c.

The simple tying of grease-proof paper over the freshly-cut stem-end in a preliminary trial was found efficacious. The delay which would be occasioned in the loading operations by the tying process or the expense of a more rapid substitute—adhesive paper or tape, or elastic binders—not to mention the cost of grease-proof paper, precluded further experiment with a view to representing it to the Trade. Experimental bunches, which were completely enclosed in large brown paper bags (1) immediately after reaping, and then shipped, were reported to have reached their destination in better condition, from the point of view of stalk rot, than naked fruit.

Vaseline is objected to on the grounds of smearing contact fruits, but we have not noticed this to any appreciable extent as only a thin coating was used. Since similar smearing materials would not find favour on the same account, various rapidly-drying sealing materials, such as acetone and collodion, two kinds of varnish, flour paste, gloy, &c., were experimented with. While for the first few days, the treated stems appeared superior to the untreated ones, the desiccation process was invariably attended with the formation of deep fissures in the stem tissue, and later the rot organisms progressed downwards in the usual way.

VII—Application to Ships' Conditions.

By courtesy of Messrs. Elders and Fyffes and the Jamaica Banana Producers Association respectively, ship conditions were studied from Santa Marta to Trinidad and from Jamaica to London. The rate of cooling of cargoes and the temperatures and humidity reactions were recorded and the concentration of carbon dioxide in the storage atmosphere analysed at intervals. In addition, the vaseline treatment was applied to experimental consignments, and the results confirmed the view that proper treatment, coupled with our earlier recommendation of more rapid cooling of cargoes, would prove effective in combatting wastage due to main-stalk rot organisms. For obvious reasons detailed results and comparisons are not entered into here.

VIII—Further Mycological Observations.

In an earlier paper (1) some account was given of the activities of various fungi which play important parts in the production of main-stalk, finger-stalk and fruit rots during storage trials. Two mycological aspects were investigated in some detail, namely, the rate of growth of the organisms at different temperatures, and their parasitic behaviour as determined by inoculation experiments. By correlating the results obtained with trade conditions of transport and storage, it was possible to submit recommendations for curtailing wastage in cargoes.

In these investigations it was demonstrated that while many of the organisms isolated grow rapidly at the normal air temperature (78° to 82° F.) their growth rates at the cool temperature of transport (53° to 55° F.) are very considerably reduced. The length of time that elapses between the reaping of fruit and cooling to 53° F., therefore, is of fundamental importance in determining the extent of infections. Thus the recommendations submitted regarding main-stalk rot aim at eliminating infections from the cut ends of the main-stalk by a process of trimming and vaselining on the quay-side immediately before loading into the holds. If the latter are then rapidly cooled to 53° F., new infections can only become established at the lower temperature, so that during the relatively short voyage and subsequent brief period in the ripening room the amount of disease developed is not extensive.

The time factor is important in determining the extent of infections at the higher temperatures, as indicated above. Even at the lower temperature of transport, however, fungal growth continues at a reduced rate, and in time existing infections become extended and may ultimately be responsible for a considerable amount of wastage. On this point the long-storage trials described in previous sections have afforded ample corroboration.

I.—Extent of Disease at the End of a Long-Storage Trial (24 Days at 52° F. then ripened for Six to Eight Days at 70° F.).

In order to extend our information on the subject of fruit diseases many isolations of fungi were made from diseased finger-stalks, finger-tips, spots, blemishes and bruises at the end of a storage trial of 24 days at 52° F.*

The following organisms were obtained: † (Table V.)

Table V.

Variety of Banana.	Finger-stalk Rot.	Blemishes and Bruises.	Spotting Diseases.	Finger-tip Rots.
Cavendish ..	*Gloeosporium musarum*; *Botryodiplodia theobromae*; *Fusarium spp.*	*Gloeosporium musarum*; *Pestalozzia leprogena*; *Eidemia sp.*; *Fusarium spp.*; *Aspergillus luchuensis*; *Phomopsis sp.*	*Gloeosporium musarum*; *Botryodiplodia theobromae.*	*Gloeosporium musarum* (several strains); *Botryodiplodia theobromae*; *Stachylidium theobromae*; *Fusarium spp.*; *Helminthosporium torulosum.*
Gros Michel ..	*Gloeosporium musarum*; *Botryodiplodia theobromae*; *Fusarium spp.*	*Gloeosporium musarum*; *Botryodiplodia theobromae*; *Helminthosporium torulosum*; *Fusarium spp.*; *Penicillium glaucum*; *Phomopsis sp.*; *Aspergillus luchuensis*; *Rhizopus nigricans.*	*Gloeosporium musarum*; *Botryodiplodia theobromae*; *Pestalozzia leprogena*; *Helminthosporium torulosum*: Unidentified fungus; *Phomopsis sp.*	*Gloeosporium musarum*; (several strains); *Botryodiplodia theobromae*; *Fusarium spp.*
Lacatan ..	*Gloeosporium musarum*; *Botryodiplodia theobromae.*	*Gloeosporium musarum*; *Botryodiplodia theobromae.*		*Gloeosporium musarum*; *Botryodiplodia theobromae*; *Helminthosporium torulosum*; *Acrothecium sp.*
Hybrid GM x B2			*Gloeosporium musarum*; Unidentified fungus.	

* We are much indebted to Mr. S. F. Ashby of the Imperial Mycological Institute for verifications and identifications.

† A few fungi mentioned in Table V did not occur during long-storage trials but are recorded here for convenience. Other references are made to them in the text.

The examples of bruising and finger-stalk rot were of the types described in our previous work, but accentuated by the long period in storage.

I I.—Fruit Spotting Fungi.

Various fruit spotting fungi on the hybrid GM x B2 (I.C.I.), the Gros Michel and the Cavendish are described in some detail. When inoculation experiments, using the methods described in our earlier paper, were carried out under typical storage conditions with *Pestalozzia leprogena* and *Helminthosporium torulosum* (*Cercospora musarum*, Ashby), negative results were obtained with the former and positive results with the latter, the fungal injury consisting in a blackening and blemishing of the skin, while the flesh remained unaffected even at maturity.

I I I.—Finger-Tip Diseases.

A number of finger-tip diseases have already been described by other investigators (3). These arise from infections of the perianth or style at the distal end of the finger and by progressing along the fruit may cause a considerable amount of rotting. Even though the flesh may be but slightly attacked, such infections render the fruit decidedly unsightly and unsuitable for marketing.

The finger-tip diseases already described include :—(i) "Black-tip Disease" of the Cavendish banana in Bermuda, caused by *Helminthosporium torulosum* (Syd.), Ashby, comb. nov. (*Cercospora musarum*, Ashby). We have observed this disease on the Cavendish in Trinidad, and the causative fungus has also been isolated from spots and bruises on Gros Michel fruits, and also from a black-tip disease of immature Lacatan fruits. (ii) "Cigar-End", caused by *Stachylidium theobromae*, Turc.; this disease is important in the Canary Islands, where a hand control is necessary. It has also been reported from the Gold Coast, the Azores, Panama and Queensland, and has been observed by us on the Cavendish banana (Governor) in Trinidad. (iii) *Gloeosporium* tip-rot; a tip-rot of the plantain has been recorded from India.

During our mycological investigations five tip-rots, to wit, *Botryodiplodia* tip-rot, *Gloeosporium* tip-rot, Cigar-End, black-tip of the Cavendish and Lacatan and a *Fusarium* tip-rot have called for more detailed attention. These may now be dealt with briefly.

Botryodiplodia Tip-Rot.

In our earlier studies *Botryodiplodia theobromae* (Pat.) was frequently isolated from severe cases of main-stalk rot and occasionally from diseased finger-tips and finger-stalks of several varieties. Inoculation experiments on wounded fingers and finger-stalks over short storage periods at 53° F., however, yielded minor blemishes only.

During long-storage trials, however, a finger-tip disease of the Gros Michel, Cavendish and Lacatan varieties was of frequent occurrence. In contrast to the usual localised disease which follows mechanical injury, this tip infection appears to originate in the decayed perianth or style from which it spreads uniformly along the fruit, causing a progressive brownish-black discoloration of the skin. The disease, which becomes prominent as the fruit is approaching maturity in the ripening room, may sometimes affect two-thirds or the whole of the finger, the flesh being rendered soft and pulpy or even semi-liquid, with a sweetish odour, while the skin becomes soft and wrinkled and covered with pycnidia. In a number of different experiments which are described, this tip-disease was reproduced by artificial inoculation.

Gloeosporium Tip-Rot.

In previous storage trials a strain of *Gloeosporium musarum* characterised by bright salmon-coloured acervuli (spore masses) was of frequent occurrence, infections on lateral bruises at the finger-tips being a usual feature of most consignments.

As maturity was being approached in the ripening room, after the long-storage trials described in Section V a finger-tip disease, apparently originating in the decayed perianth and spreading slowly backwards from the finger-tip for 2 cms. or more, was much in evidence on both the Cavendish and Gros Michel varieties. The affected tips became dark brown in colour with a gradual transition through a watery-looking, greenish-brown margin, to the normal healthy yellow skin.

At the same time the flesh within was slowly exploited, and after attack consisted of moist disintegrated pulp, with a watery margin where deeper invasion was taking place. At a later stage the brownish-black region became covered with the brownish acervuli of a strain of *Gloeosporium*.

Inoculation experiments parallel to those described for *Botryodiplodia* were carried out using the strain of *Gloeosporium* isolated from typical cases of tip-rot, and characteristic infections were obtained.

Cigar-End.

This is not a storage disease but one which occurs in the field, the fruits being apparently most subject to infection in their more immature stages. Sometimes only a few fruits are affected, but at other times every finger in the bunch may show some degree of infection. Characteristic examples have been observed by us in Trinidad. The infection apparently originates in the perianth. From there it slowly spreads backwards along the finger, causing a shrinking and blackening of the skin while the diseased region becomes covered with the powdery grey spores of *Stachylidium theobromae*, Turc., which give the characteristic resemblance to a burnt cigar tip. The flesh within is slowly exploited by the fungus and is left in a dry, rotted condition. The disease made

no further progress when fruit was taken into storage and kept under the usual trade conditions. From such material cultures of *S. theobromae* were consistently isolated.

Black-Tip Disease of the Cavendish and Lacatan.

A "Black-tip" disease of the Cavendish banana has already been described from Bermuda, where it was demonstrated by inoculation experiments that the causal organism was *Helminthosporium torulosum,* (Syd.) Ashby, comb. nov. (*Cercospora musarum,* Ashby). Ogilvie's description of the symptoms is as follows:

"Under certain conditions a black discoloration becomes apparent just below the flower and progresses down the fruit. In about three weeks' time it may progress some two inches down from the tip. The diseased area is frequently irregular in outline, often affecting one side of the fruit more than another, and is bordered by a narrow grey or light yellow margin. An ill-defined zonation is frequently present."

A very similar tip infection of the Cavendish and Lacatan varieties has occasionally been observed by us.* In older infections the blackened areas were frequently disrupted apparently as the result of insect activity. Superficial scrapings, on microscopic examination, yielded spores of several fungi including *Fusarium* spp., *Acrothecium* sp. and *Helminthosporium torulosum,* while the latter was also isolated from the innermost affected tissues.

Fusarium Tip-Rot.

In some of the long-storage trials a tip-rot of conspicuous appearance was occasionally observed in the Gros Michel. An early stage of the infection consisted in the development of a dark watery-looking zone round the distal end of the finger. This discoloration spreads slowly along the fruit over a distance of one to two inches, while in the older infected regions, as maturity was reached, the skin developed a dark sooty appearance, more or less obscured by the development of a mat of pink mycelium of velvety texture. In the vicinity of the distal end the flesh was reduced to a semi-liquid consistency by the invasion of fungal hyphae. Small samples, taken from the junction of healthy and diseased tissue, when grown on culture media consistently yielded the same species of *Fusarium.* It remains to determine by inoculation experiments the conditions under which the invasion of finger-tips by the organism takes place.

IV.—Latent Infections.

Dastur (4) noted that fruit may be infected by *Gloeosporium* long before it gets ripe but that the fungus remains dormant until favourable conditions for attack arise. When a similar experiment was carried out by us important *Gloeosporium* and *Botryodiplodia* infections were much in evidence at the end of ten days at 78° to 82° F., typical specimens of tip-rots, finger-stalk rot and disease spots being obtained.

All diseases present at the end of a storage trial cannot be assigned to latent infections. The latter, however, obviously constitute an important potential source of wastage and only require suitable temperatures to become manifest. Further, when they are present they cannot be combated by preventive measures based on surface sterilisation, since it has been shown that they escape destruction when the usual experimental methods are carefully applied. On the other hand when fruit is expeditiously cooled to 53° F. and quickly ripened at the end of the transport period, ripe fruit can be obtained before the damage due to latent infections becomes excessive. This was confirmed by doubly sterilising fruit and placing in 53° F. for 16 days, followed by ripening at 70° F. Only minor infections were in evidence when maturity was reached.

IX—Summary and Concluding Observations.

1. In these investigations the object was to define the limits of chill, with a view to placing on a definite footing our previous recommendation of quick cooling as a preventive measure for main-stalk rot and other sources of fungal wastage in banana cargoes. The storage trials carried out at 51° to 52° F., have shown that chilling is a cumulative effect of duration of exposure, and not the result of rapid cooling, to such temperatures. In actual practice the banana is transported by the bigger companies at a temperature of approximately 53° F. to which temperature the cargo is reduced in the course of four to five days. More rapid cooling than this is popularly believed to involve risk of chilling, with concomitant failure to ripen regularly or ripening to a dull colour, but our researches have corroborated strikingly our earlier recommendations that this temperature is definitely not inimical no matter how quickly it is reached, provided delivery temperature of the air is not lower than 53° F. On the other hand, we have obtained chill effects (*vide* above) by:

(*a*) *Gros Michel.*
  (1) exposure of 14 days at 52° F.
  (2) exposure of nine days at 51° F.

(*b*) *Cavendish.*
  (1) exposure of 13 days at 51° F.

2. Since this work definitely aims at providing information for the Trade, our practice has been the more and more rapid cooling to progressively lower temperatures than those usually adopted, and we have now established, contrary to previous information, that *the rapid cooling to* 53° *F.*

* In the case of the Lacatan the first specimens were brought to our notice by Mr. R. T. Wigglesworth and Mr. W. F. Gwilliam who observed them while studying the behaviour of this variety as a field crop.

within 12 hours may be practised without danger of chilling during the usual voyage of 16 to 20 days. This will bring in its train the advantages of retarded fungal activity with consequent decrease in wastage.

3. While from the purely mycological standpoint the benefits of temperatures lower than 53° F. are evident, we do not recommend them, since in the resultant comparatively slower ripening, fungal activity is responsible for relatively extensive wastage.

4. The number of ways in which chill effects manifest themselves include (i) failure to ripen, (ii) poor colour, (iii) russetting, (iv) "green-ripeness" and (v) "hard-ripeness".

5. In the course of further bulk storage trials the Cavendish as exemplified by good specimens of the Trinidad "Governor," again commends itself as a possible substitute for the Gros Michel.

6. In the course of both senescence and long-storage studies, the superiority of this variety in the matter of cold endurance has been repeatedly observed—a qualification which should prove particularly advantageous on the longer journeys.

7. Pre-storage, nutritional, time and temperature factors are of fundamental importance in determining the extent of wastage due to fungal activity in banana cargoes. In particular the longer storage trials at 52° F. and 51° F. stress the importance of the time factor in this connection.

8. Latent or dormant infections established while the fruit is still immature may be responsible for extensive wastage, if fruit is not expeditiously cooled and quickly ripened. Such diseases cannot be combated by superficial sterilisation of the fingers but may be minimised by suitable observation of temperature relations.

The foregoing is an account of research work conducted by the Physiologist and Pathologist in collaboration at the Low Temperature Station, Imperial College of Tropical Agriculture, Trinidad, B.W.I., and they again avail themselves of the opportunity of expressing their thanks to the Principal and members of the Staff for their helpful co-operation.

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THE WORLD'S COTTON MARKETS.

BY JOHN A. TODD, M.A., B.L.

Concluded.

II. The Futures Markets.

So far for the various stages of the marketing of actual cotton. We have now to deal with the other and equally important side of the world's system of cotton markets, namely the Futures markets. To explain the function of these markets it is necessary to recall that the objects of a marketing system are three-fold:—(1) to ascertain the proper price of every item of the commodity which passes through the market, (2) to secure uniform prices for similar cotton throughout the whole world market, so that for example American cotton will not be dear in Liverpool while it is cheap in New Orleans, or that Punjab-American if it is really as good as American, will not be selling at an unfair discount, and (3) to maintain as far as possible the stability of prices over periods of time, by smoothing out the inevitable fluctuations due to the variations of supply and demand. The last two of these functions can only be fulfilled by a system of communication which enables all the sellers and all the buyers throughout the whole cotton world to know at any moment what price their cotton or similar cotton is fetching in any part of the world. Such communication must nowadays be by telegraph, and one of the main purposes of the great organised cotton markets of the world is to maintain such communication, so that every scrap of information or every breath of opinion as to the prospects of supply or demand may be instantly communicated to all the other markets. Thus a Washington Bureau Report issued simultaneously to all the representatives of the press and cable companies in a small room in the Department of Agriculture at Washington exactly to a second at 11 o'clock on the morning of 8th August is, within a matter of seconds, communicated to every cotton exchange not only in America and Europe but also to Alexandria, Bombay, Japan and all the minor producing countries throughout the cotton world; and when after twenty minutes' interval the big markets reopen, their views of the effect of that report, as shown by the movement of prices, are instantly communicated to each other and to all the rest of the world.

But how is it done? What price can be instantaneously flashed all over the world, for obviously only one price, or at the most two or three, can possibly be so treated. The answer is that the cabled quotation is the "Futures" price of Middling American cotton, for the price of American cotton dominates the world price of cotton of all kinds, and every change in the price of American is promptly reflected in the revision of the price of every other variety. In the case of Indian and Egyptian there are also Futures markets in Bombay and Alexandria

respectively, and in Liverpool there are Futures markets for Egyptian, East Indian (only started this month) and also for Empire cotton. What then is this Futures price? What does it mean and how is it fixed?

To answer this question it is necessary to explain just what a Futures contract is, for popular opinion on this point is entirely at sea. In the first place the apparently obvious distinction between Spot and Futures contracts, namely, that one is for immediate delivery and the other for future delivery, is entirely misleading. As a matter of fact contracts in the Spot market may be for deferred delivery over as much as 12 months ahead, *e.g.*, a contract for say 100 bales in each month for a year ahead, which is popularly known as selling "round the clock". On the other hand a Futures contract for the "near month" as it is called might be completed by delivery within the current month, and conceivably might be followed by a tender almost the same day. Again the man in the street thinks that Futures are pure speculation or just gambling, because these contracts are not intended to be completed by delivery but merely to be settled on differences. But while as a matter of fact many Futures contracts are cancelled by buying in or selling out before the date provided for delivery, yet the contract is in form just like any other contract for the sale of actual cotton. It is a contract for the delivery of 100 bales of cotton within a certain month and at a price stated; and everyone in the cotton market knows that the buyer of such a contract is liable to have cotton tendered to him if he lets it run into that month, while the seller knows that he will be called on to deliver the cotton by the end of that month if he has not previously bought in a similar contract. The man in the street who merely takes a "flier" at cotton when he thinks it is going up may not know this, but he knows that he can sell out before the due date at a profit or a loss.

The fundamental difference between contracts in the Spot market and those in the Futures ring is that a Spot or C.I.F. contract (the latter being a contract for the sale of cotton to be imported) specifies exactly, either by sample or description, the particular kind of cotton to be delivered under the contract, while a Futures contract might be called a "basis" contract; the contract merely specifies the basis price of Middling American cotton, but the buyer has the right to deliver anything above or below that grade (within certain limits) and the price to be paid for the cotton actually tendered will be decided by arbitration at certain differences, expressed in decimal points of a penny per pound and hence called "points on" or "off" the basis price of Middling American.

The advantage of this peculiar form of non-specific contract is that, just because of its vagueness, anyone can buy it or sell it with the result that the volume of trading is enormous and this becomes an argument in a circle. Just because the market for such contracts is so large it has come to be very widely used for another purpose, called "Hedging." Suppose for example that a merchant in Liverpool has imported 100 bales of good staple American cotton at a price considerably above the price of ordinary Middling cotton, and for it he hopes to find a buyer at its proper price; but it will take time, first to get the cotton brought to Liverpool and then to find the particular spinner who wants just that class of cotton. In the meantime, however, owing to some change in crop prospects the price of all kinds of American cotton might fall very substantially, and the importer stands to lose heavily while he is waiting. If, however, when he buys the 100 bales he sells 100 bales of Futures then, whatever happens to the price of cotton in general, he will be protected against loss because when he comes to sell his actual cotton he can buy in his Futures contract at a profit which will cover the loss he has made while holding the actual cotton. But the possibility of such a hedge depends on the fact that he can go into the market and sell Futures at any moment, and when he has sold the actual cotton, go into the market and buy the Futures contract back again whenever it suits him. In other words the system of hedging depends absolutely on the existence of a large free market for such Futures contracts, in which there will always be buyers and always sellers at a price.

This volume of Futures business is maintained primarily by the increasing use of hedging by all kinds of people interested in cotton, *e.g.*, a spinner who is offered a contract for yarn deliverable over many months ahead, cannot take the risk of accepting it unless he has already secured his cotton; but to do so would involve a heavy outlay of capital and expense for storage. If, however, he buys Futures he has no capital outlay, yet he is insured against the risks of the market rising against him before he buys the actual cotton. Again a spinner who in order to keep his mills running has made for stock a large quantity of yarns which he cannot sell in the meantime, is running a grave risk if the raw cotton market goes down, but by selling Futures he can cover himself against this risk, for if the market falls and he loses on the price of the yarn stocks he makes a profit on his Futures contract when he ultimately sells the yarn and buys in the contract. These are merely illustrations of the innumerable interests in cotton which may be covered or insured by the various parties through a hedge, which may therefore be defined as a collateral contract by which any party interested in actual cotton may insure himself against the risk of fluctuations in the price of raw cotton; and so widely has the practice of hedging been extended that it may now be assumed that every contract which involves an obligation on someone to buy or sell actual cotton is covered by a hedge contract in the Futures market.

It may be asked, however, how it comes about that there are always just about as many buyers as sellers or *vice versa* in the Futures market. The answer is that, in addition to those who wish to hedge their interest in actual cotton, there are in the market many speculators in the best sense of the word who, "taking a view" of the prospects of cotton, are prepared to buy Futures when other people wish to sell, in the hope of selling later on at a profit when other people wish to buy; and the existence of a volume of such intelligent anticipation is essential to the existence of the Futures market. Thus in the autumn when the bulk of the American crop is moving to market and all the exporters are buying actual cotton in the Belt and hedging every 100 bales they buy, the whole weight of the crop is thrown on the Futures market; and the actual demand from spinners and importers in the consuming countries could not take it up without the help of legitimate speculation by those who are prepared to carry the crop until later on in the season when actual consumption will take it off their hands. These speculators therefore "make the market" which would otherwise be all one way for half the year, and all the other way for the other half, which of course would be a very bad market.

In addition to this legitimate speculation, which is really investment buying, there is of course in every Futures market a certain amount of outside speculation by people who have no interest in actual cotton at all, and merely wish to have an occasional "flutter" in cotton, generally when something spectacular has happened to the crop which they think will put prices up. Such speculation is of doubtful advantage because it is usually very ill-informed, and the tendency is for such gamblers to follow the crowd and carry things to extremes. But even this kind of buying has its uses, for every additional buyer or seller helps to make a market, and these people are usually the heaviest losers when the break comes.

It only remains to mention another very important class of speculators in the market, namely, the "Jobbers." These are people who, being very closely in touch with the market, watch the smallest fluctuations from hour to hour, and generally confine their operations to a single day. In Liverpool, for example, they will sell in the morning when there is a pressure of buying orders from Lancashire and buy in again in the afternoon when hedge sales begin to come in from New York; for it must be remembered that New York is five hours behind Liverpool and their opening at 10 a.m., does not come through to Liverpool until 3 o'clock in the afternoon. These Jobbers also help to make a market and serve a very useful function.

Such then is the general structure of the Futures markets. They are focussing points of supply and demand, both present and prospective, and their effect is on the whole to minimise the fluctuations of the price of cotton in general by anticipating the changing conditions of supply and demand. But the existence of such markets also serves what we have described above as the second function of a world market, they keep the various markets in touch with each other and communicate any change in prices all over the world immediately. Thus it is Futures prices that are kept uniform by the cable system, and Spot prices follow the Futures market, so that the maintenance of uniform prices for actual cotton is achieved through the Futures market. The next question therefore is the effect of the Futures market on Spot prices and *vice versa*. Is it the actual conditions of supply and demand, as affecting the Spot markets, which are reflected in the fluctuations of the Futures markets; or is it as some people believe that the price of cotton is fixed in the Futures markets, and the values of actual cotton are dragged up or down, regardless of the real conditions of supply and demand, by gambling in Futures?

The answer to that question may best be found by returning for the moment to the Spot market to see how it uses the Futures market in its work of selling actual cotton; and to explain this fully it is necessary to enter into a rather detailed account of the methods of the Spot market. It will be remembered that the Futures contract affects only the basis price of Middling American, but very little actual cotton would come exactly within the description of "Middling cotton, fair staple" which is the basis of the contract. Most cotton is either better or worse than that, and the cotton market as already mentioned has developed the habit of expressing these differences of value in "points on" or "points off" the price of Middling. The universal adoption of this practice, combined with the universal use of hedging by the merchants, has produced a peculiar result. When a spinner comes to buy cotton he is shown samples, but the prices are never stated in actual pence. All he is told is that this cotton is say "150 on May", meaning that if he buys that cotton in February for delivery in May, the price he will have to pay will be 1½*d.* a lb. above the Futures price for May. Now very often the spinner hopes to require that cotton some time between now and May, but he may not have sold the yarn which he would make out of it, and rather than buy the cotton and pay for it, it suits him better to say something like this: "All right. I will take that cotton some time between now and May but you must leave it to me to say when I want it." This is known as a "Spinners Call" contract and it means that when the spinner gets an offer for the yarn he will calculate his selling price on the basis of the Futures price for May, whatever it may be by that time, plus the 150 points on. When he fixes the yarn sale he telephones his broker to "call 100 bales" under that contract, whereupon the broker fixes the price by going into the market, buying back

his 100 bales of Futures, and then invoicing the cotton to the spinner at the price he paid plus the 150 points.

The almost universal adoption of this system has led to the rather puzzling result that merchants in Liverpool do not deal in cotton at all, but merely in "points on", and their whole business is to make their profit out of these differences. That is by no means easy, because not only does the price of cotton, as shown by the Futures quotation, vary all the time, but the amount of the differences which a particular grade or staple of cotton will command above or below the basis price also varies, and it may vary quite differently from the movement of the basis price. Thus cotton may be falling but the premium for good staple cotton may be rising at the same time. This risk of the variation of the premiums or discounts on different grades of cotton is one which the merchant cannot cover by hedging, because his hedge contract only protects him against variations in the basis price. Unfortunately the cotton market has here introduced a complication which makes it extremely difficult for the outsider to follow their jargon. They have got into the habit of speaking of these differences or "points on" as "basis" which is simply a shorthand method of saying points on or off the basis price. When therefore they say the "basis" for good staple cotton is rising, they mean that the premium commanded by such cotton is greater; but the actual price of such cotton may be falling, because of a fall in the general price of cotton as represented by Futures. This is the explanation of such statements as that "the basis is rising" or falling; and again it explains the cryptic statement that "basis cannot be hedged".

Thus the Liverpool Spot market deals only in basis. The price of cotton in general is of very little importance to the Spot man; he has covered all that by his hedge contract, and his business is to make his profit out of the basis, in his sense of the word. This may seem to the outsider an entirely unnecessary complication, but it has a great advantage. In effect it means that the Liverpool market (and other big markets are similar), is divided into two separate markets: (1) The Futures market deals with the price of cotton in general, and has little interest in the particular fluctuations of supply and demand that affect different varieties of cotton. (2) The Spot market practically ignores the price of cotton, and confines itself to the variations in value of different cottons. The result is specialisation, and the development of an extremely high degree of skill and knowledge, for each section of the market is left free to mind its own business, and becomes expert in calculating the innumerable risks and chances which affect prices in its own department.

But while the two sections of the market are thus separately organized they are intimately bound up with each other, so that the movement of the actual conditions of supply and demand in one market is very promptly reflected in the other. The link between Spot and Futures lies in the fact that every sale of actual cotton is promptly covered by a hedge contract in the Futures market. Thus when the bulk of the crop is moving to market during the harvesting season the weight of hedge selling tends to depress the Futures market, unless there is an unusually active offtake of actual cotton by spinners. On the other hand when the spinners are "calling" cotton freely the result is a great deal of price fixing, *i.e.*, Futures being bought in, so that prices rise. Further, any tendency for the Futures market to run away from Spot conditions in either direction is always checked by the fact that the Futures contract is after all a contract for the delivery of actual cotton, and if Futures prices get out of range of Spot values the other party to the contract can always resort to the actual transaction. If for example Futures get too low, the holders of the contract may decide to take up the cotton, and those who have sold "short" may find it difficult to lay hands on the actual cotton to fulfil their contracts, as in the case of the squeeze in May Futures last year, described in the previous article. On the other hand if Futures go too high, the sellers can always tender the actual cotton; and as a matter of fact experience prior to 1930 seemed to show that this was the more normal course of events, and the "fear of tenders" often proved a depressing factor because the "longs", *i.e.*, those who had bought contracts, were afraid of getting delivery of undesirable cotton. It sometimes happened, therefore, that the presence in the market of quite a small quantity of cotton, which for some reason was a drug in the market at the time, would prove a depressing factor for several months, because as each month came round there was the fear that it would be tendered. Thus the Spot and Futures markets act and react on each other, and the correlation of prices is on the whole remarkably good.

It seems then that cotton growers generally have not much cause to complain of the way in which the great organised cotton markets of the world handle their product. The truth is that most of the faults in the system lie very near the growers' own door. It is the primary markets that are lacking in proper organisation, and the cure for that is no easy matter. The recent attempts by the American and Egyptian Governments to help the growers to improve conditions at their own end of the business have unfortunately resulted in these governments being dragged willy-nilly into intervention on a very large scale in the working of the organised world markets, which so far has resulted mainly in disorganising these markets very badly. How the whole business will end is still very uncertain, but the conclusion is that it is foolish of the growers to try to blame all their troubles on other people at the other end of the marketing system. They must put their own house in order

FUSARIUM WILT DISEASE OF SUNN HEMP.—I.

BY

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History of Crotalaria Wilt.

Reference to this disease in phytopathological literature is meagre. Vincens (15), in 1921, reported the occurrence of a wilt affecting *Crotalaria juncea* and *Crotalaria usaramoensis* in Tonkin. He described the malady as a collar disease, similar to the wilt diseases of pigeon pea and cotton, and with the root or the base of the stem serving as the point of attack. From diseased specimens he isolated species of Fusarium, Neocosmospora, Melanospora, Cucurbitaria and Diplodia but the only fungus constantly present was a Fusarium which was closely allied to *Fusarium udum* Butl., and this he suggested was the causal organism. His inoculation experiments were unsuccessful but he considered this attributable to wrong conditions for infections by the fungus.

In 1924, Van Hall (14), in the Dutch East Indies, recorded the occurrence of a wilt disease of *Crotalaria usaramoensis*, caused by a species of Fusarium but furnished no details.

Fusarium wilt of *Crotalaria juncea* was recorded in Trinidad for the first time by Briant and Martyn (1), and the only known occurrence was at the Imperial College of Tropical Agriculture farm at St. Augustine. Their work included the isolation and the establishment of the parasitism of the fungus, which they found to resemble *Fusarium udum*, and also a short description of the symptoms and course of the disease.

It was decided to proceed with further observations on the disease and with a study of the effect of agricultural methods on its occurrence and also to conduct a parallel study on the wilt disease of *Cajanus indicus*.

Sunn hemp wilt, apparently, is by no means common and no work has been done on the control of the disease but control methods for the allied wilts of pigeon pea and cotton have been sought by several plant pathologists.

Investigations on pigeon pea and cotton wilt.

In India, pigeon pea wilt was studied for the first time by Butler (2), who named the pathogen *Fusarium udum*, but later (3) recognised it as a biologic strain of *Fusarium vasinfectum* Atk., the causal organism of cotton wilt. Included in his tests on the control of the disease were sulphate of iron and lime which he found were ineffective. He concluded that no simple control methods were available and that it remained for the plant breeder to find immune varieties. At Pusa, McRae and Mitra (6) have continued over several years, experiments on the checking of this wilt by repeated applications to the soil of the common manures. The results of observations on the permanent experimental plots, though not conclusive up to 1928, show that green manuring may be beneficial and that superphosphate may increase the incidence of the disease.

The great economic importance of cotton as a crop, has led to a wide study of its wilt disease, especially by American workers. Much work has been done on control but the results achieved by the various workers are conflicting. Orton (8), in 1908, published a popular account of the disease. He found that modifications of the fertilizer formulae were without effect on the control of wilt. Kainit was quite as ineffective when applied at the rate of 2,000 and 4,000 lb. to the acre as when in smaller amounts. Stable manure gave some relief in slightly infected areas but in spite of the heaviest manuring, the crop eventually succumbed to wilt. No benefit was derived from the use of lime, which was applied at rates varying from two to six tons per acre. A large number of soil fungicides were tried regardless of the economy limit and in excess of the value of the land, but in no case was the incidence of wilt lessened. Rotations were extended up to ten years and although this resulted in a reduction of the percentage of wilt, the soil remained infected. The results obtained by Lewis, as quoted by Neal (7), corroborated those of Orton. Rast (9), on the other hand brought forth evidence to show that the control of cotton wilt could be effected by the use of potash fertilizers.

A note by Ferris (5) gives further evidence of benefit accruing from the use of potash. At the Mississippi Experiment Station, four out of 56 cotton plots, used in fertilizer trials, became infected by the wilt fungus. The usual fertilizer was 600 lb. to the acre of a mixture consisting of equal parts of acid phosphate and nitrate of soda. To test the influence of Kainit on the disease, it was applied at the rate of 300 lb. to the acre to half the rows of each plot. Nearly all the plants died on the parts without potash, while on the parts with it, a considerable number survived and the yield of cotton was almost doubled.

Neal (*loc. cit.*) tried out a number of greenhouse experiments on the effect of nutrition on the development of cotton wilt and found indications of potash, when applied in sufficient quantity increasing the degree of resistance of the plants to infection by the fungus.

He suggests that fertilization methods, especially if combined with a rotation of crops to maintain the organic content of the soil, bring about delayed infection and the plants are thus able to mature a portion of the bolls.

Rosen (10), in experiments on the damping off of cotton seedlings by *Fusarium vasinfectum*, found that plots which received only a potash dressing produced a better stand than those to which a complete fertilizer was applied. In later publications (11, 12, 13), he gave the results of his studies on the pathogenicity of the fungus. His findings were that in culture media where inorganic nitrogen is present, nitrite is produced which is toxic to the plants, but when organic nitrogen is used no toxin is produced. His conclusion was that one reason for the better stand of cotton on the potash plots was the absence of nitrate, contained in the balanced manure. He suggested that the prevalence of wilt on light sandy soils is due to the absence of organic nitrogen and that a control of the disease might be effected by the use of organic fertilizers.

Fahmy, working in Egypt, found that soils exhibited different degrees of infection, depending on the amount of infective material, obtained either by adding different quantities of inoculum or by accumulation from the cultivation year after year of a susceptible cotton. Bare fallow and treatment with carbon bisulphide were ineffective in controlling the disease and though rotation reduced the incidence to some extent, there was still a fairly heavy infection after three years.

Arrangement and preparation of Experimental Area.

Experimental plots were laid out in "chess-board" fashion in an endeavour to determine the effect on the incidence of wilt of the following :

1. Water content of the soil,
2. Liming,
3. Manurial treatment.

The allotted area was a portion of a field which was previously under a cover crop of Bengal and Sword beans. This was cut down and ploughed in and the land was then disc-harrowed. A rectangular area, 312 by 101 feet, was marked out and divided up into 48 plots, each with an area of 600 square feet and separated by paths. The area was so selected that the eastern half of the field to which lime had been applied, included 24 of the plots. The liming was carried out in July, 1928, at the rate of 10 tons to the acre, the requirement as chemically determined. Eight different manurial treatments were given with six replications of each, three on the limed and three on the unlimed portion. The disposition of the plots is shown in Chart I. The manures were applied to the surface and incorporated in the soil by hand hoeing. The individual manures used and the rate of application were as follows :—

Sulphate of Ammonia—4 cwts. per acre,
Superphosphate—4 cwts. per acre,
Sulphate of Potash—2 cwts. per acre,
Pen Manure—20 tons per acre.

One-half of each plot was left flat and the other was ridged and furrowed. The ridges were made two feet apart and 15 inches high, which was thought enough to allow of a sufficient reduction in water content for comparative purposes. Each plot was divided in half at right angles to the line of the ridges. Sunn hemp was sown on one-half and pigeon pea on the other.

Profiting from the experience of Briant and Martyn (*loc. cit.*) with poor germination, precautions were taken to ensure a uniform stand. The sunn hemp seed was sown on the flat in lines two feet apart and on the tops of the ridges. After the seedlings appeared through the ground they were thinned out to leave little clumps 12 inches apart. A day or two later the hardiest seedling in each clump was selected and the rest were removed. This method gave a uniform stand of 144 plants per plot. A similar stand was obtained in the case of pigeon pea by making holes one foot apart and placing three seeds in each. Thinning was carried out later, where necessary, to leave single seedlings.

Sowing was commenced on the 24th of October and was finished about a week later. Sunn hemp, grown in this field the previous year, had shown a big percentage of wilt. Deeming, therefore, that the soil would still be infected with the wilt-fungus, no artificial inoculum was applied. The sunn hemp plots were examined every second day up to the time of harvest and observations on the incidence of wilt were recorded. During the early stages of development of the plants, hoeing injuries, mole cricket and a species of Colletotrichum were extraneous causes of death. Many of the seedlings were attacked by the Colletotrichum but in most cases they managed to grow away from the disease, although the lesions produced by the fungus were persistent.

Symptoms and course of Wilt Disease.

These were much the same as observed by Briant and Martyn but a few points additional to their description were noted. They state that sunn hemp is attacked by wilt in the seedling stage but in the present instance the plants were a month old before any showed the external symptoms of the disease.

The first signs of wilt among young plants were best observed in the evening. The leaves of a healthy plant, towards evening, turn upwards at a very acute angle so that the under surface is exposed. In the case of a plant attacked by the wilt-fungus the leaves showed no such movement. The following day it was usually found that the leaves withered, turned brown and dropped off in acropetal succession and by evening the plant was dead. At a slightly older stage, some plants were observed to droop over at the tip before wilting and defoliation took place. After branching had taken place, the attack was usually confined to part of the plant only and a general wilting of the plant was comparatively rare.

After death the sporodochia of the fungus were produced on the dead stems or on the dead portions of such stems where the infection was confined to one side, and these imparted a pinkish tinge.

On slitting a wilted plant with a sharp knife, it was usually found that the discoloration of the tissues could be traced to the apex of the main tap root, where wilting had been general and to the apex of a lateral root, where wilting had been confined to one side of the plant only. It might be concluded, therefore, that the root tip was the point of infection. Uprooting and slitting a plant showing the first symptoms of wilt usually revealed the fact that the discoloration originated in the root.

All plants examined, both from the ridges and from the flat, exhibited abnormal swelling accompanied by growth cracks at the collar region. This may have been due to the irregular water supply, occasioned by short periods of drought alternated with periods of partial flooding, while excessive fertilization was probably an accessory factor. It seemed in some instances that a growth split had provided the point of entry for the fungus, for the discoloration had its origin there, travelling upwards into the stem and downwards into the root.

The fungus was found to permeate the wood in all directions and hyphae bearing microconidia were observed in the larger vessels. The discoloration of the tissue was largely due to the presence in the vessels of gum and mycelium in quantity sufficient to cause a partial plugging.

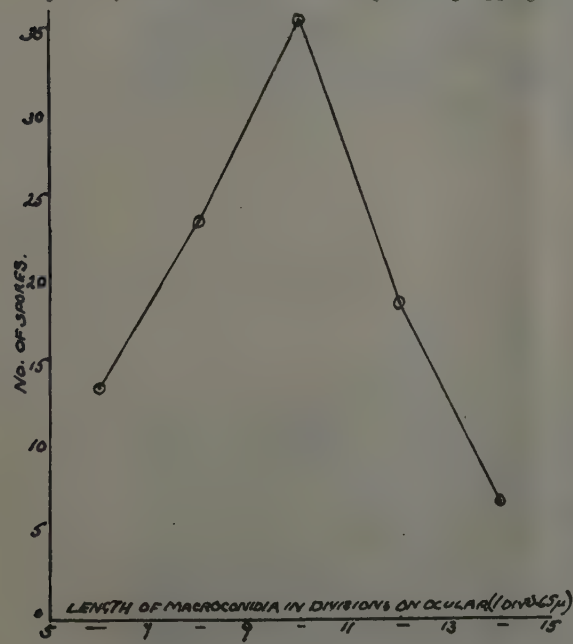

Fig. 1. Curve of macroconidium length.

Etiology.

The fungus causing the disease is a species of Fusarium. Observations on the growth on different media confirm those made by Briant and Martyn (*loc. cit.*) and it seems probable that the pathogen is a biologic strain of *Fusarium vasinfectum*. In culture, micro and microconidia were produced early and abundantly and later chlamydospores and minute sclerotia were formed.

The microconidia varied within wide limits in size; they were usually unicellular but occasionally uniseptate. Briant and Martyn measured the macroconidia from a five weeks old culture on potato agar and gave the average size as $40\mu \times 4\mu$, with the range in length $29\mu - 47\mu$.

Spores produced on the exterior of diseased plants were taken and measurements of 100 macroconidia gave the following figures:—

Range in length $= 54.8\mu - 18.3\mu$.

Range in breadth $= 4.0\mu - 2.9\mu$.

Average size of macroconidia $= 33.4\mu \times 3.7\mu$.

The septation varied from one to five but 75 per cent. of the spores were triseptate.

Incidence of Wilt on the Experimental Area.

On the experimental area the initial outbreaks of the disease were observed to occur in certain well defined areas and the plots infected soon showed a heavy percentage of wilt. A plan was made of the whole experimental area and on it were mapped out the positions of the wilted plants. A plan, on the same scale, of the area used last year was superimposed and it was found that the outbreaks of the disease had occurred distinctly within those areas which had previously been planted to sunn hemp. (Chart 1.)

A record was kept of the date of the appearance of all cases of wilt up to the time when the plants were ready for harvest, which was 15 weeks from the time of sowing. In the few days which elapsed between this and the actual reaping, several plants showed symptoms of wilt for the first time but these were neglected since the attack was too late to affect the crop.

The positions of all wilted plants were entered in a second chart, after each inspection of the experimental area, and a series from Chart I, was compiled by photographing this second chart at the end of the 6th, 8th, 10th and 15th week. There was not sufficient difference between the 12th and 15th week to warrant a photograph of the former. (Charts 2, 3, 4, 5.)

From the various charts, several points may be discerned.

CHART 1.—Except for one isolated plant in plot F (IV), the disease was initially confined to those areas which were planted to sunn hemp in 1927-1928.

CHART 2.—The incidence of the disease increased rapidly within these areas, especially on Plot B (III), and further isolated plants were attacked. The occurrence was somewhat marked in the plots bordering the north side.

CHART. I.

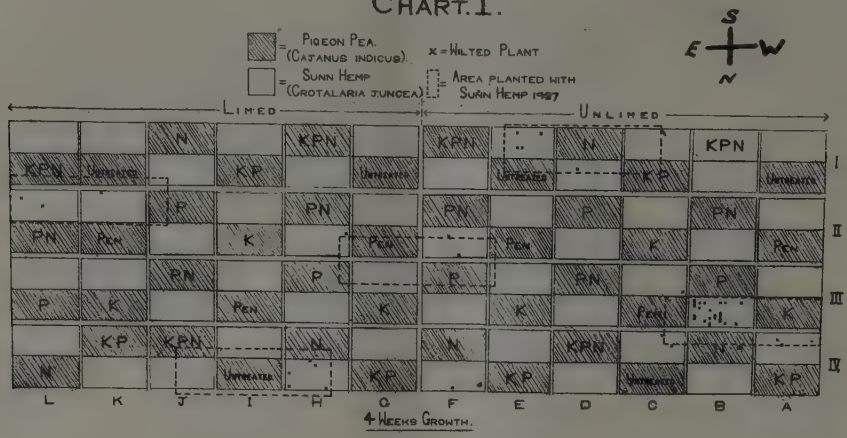

CHART. II.

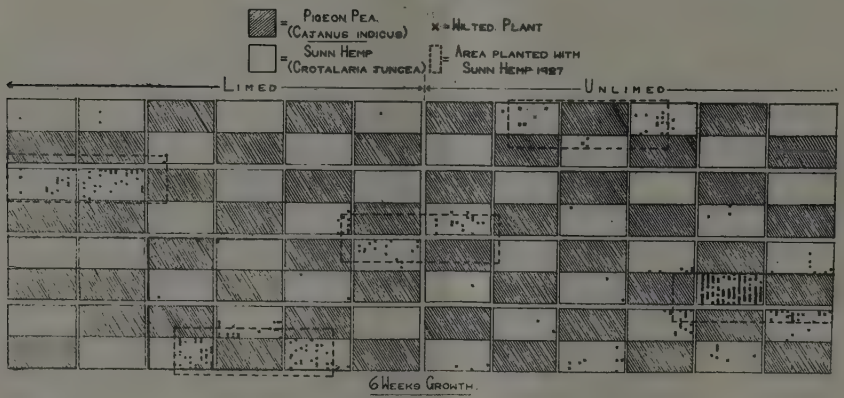

CHART. III.

CHART IV.

CHART V.

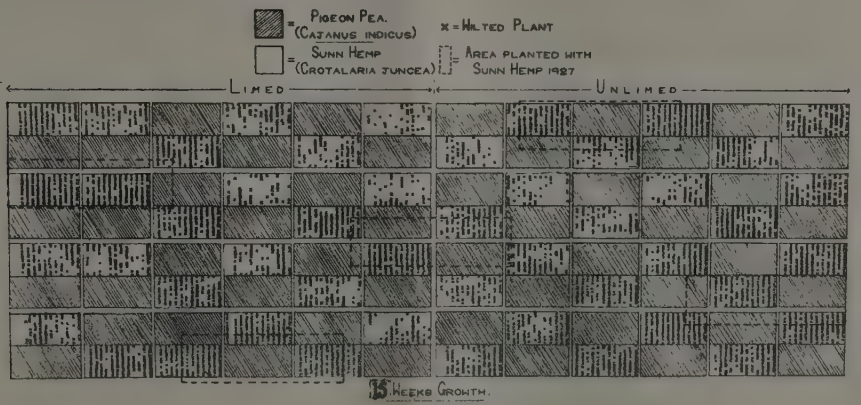

CHART 3.—A spread of the disease from the former sunn hemp areas took place in a more or less radial manner. There were indications, also of the disease spreading round some of the isolated plants which had wilted. In some plots a small group of plants wilted simultaneously.

CHART 4.—Nearly all the plants within the sunn hemp areas succumbed to the disease. The indications in Chart III became more distinct.

CHART 5.—Throughout the whole of the crop infection was general and the plots which showed least wilt were those which were furthest removed from those areas which had previously borne sunn hemp.

Effect of water content of soil.

At the time of sowing there was very little rain and, consequently, germination and establishment of the seedlings proceeded more rapidly on the flat. A rapid increase in the rainfall followed, which stimulated the plants on the ridges to quick growth while it retarded the growth of the plants on the flat. A partial flooding of the land at intervals, caused by the heavy rainstorms, resulted in certain areas becoming waterlogged and such areas were marked out for observation.

The occurrence of wilt, however, was uniform throughout. As many plants died from wilt on the ridges as on the flat, and water-logging, though it accounted for the death of several seedlings, was so far as could be judged without effect on the incidence of the disease.

Effect of lime and manurial treatment.

It was anticipated that the application of lime at the rate of 10 tons to the acre would appreciably alter the reaction of the soil. The pH determinations of samples of soil from various parts of each of the unlimed and limed portions of the field showed that the alteration was slight. On the unlimed portion the range was from pH 6.0 to pH 6.2 and on the limed portion from pH 6.4 to pH 6.6. Constancy of the latter determinations show that the lime, though applied comparatively recently, had become well incorporated in the soil. The difference in reaction did not affect the pH value of the plant sap which was constant at pH 6.5 in all the plants examined.

For the purpose of comparing the effects of the different treatments on the incidence of the disease, the following procedure was adopted to calculate the percentage of wilt on each plot. Differential effects due to the propinquity of

other plots were eliminated by leaving a buffer row round each plot, thus removing 44 plants in each case. Plants which had died from extraneous causes were discarded and the percentage of wilt was calculated on the remaining number.

Table I shows the manurial treatment given to the plots on the unlimed and limed portions of the field and the incidence of wilt in each case. The thick black type indicates the plots which lay wholly or partly within the areas which had previously been planted to sunn hemp.

The destruction of the crop within these areas was independent of the treatment given and was nearly complete. On the plots outside the areas the incidence of the disease was neither as heavy nor as uniform. As indicated in Chart V, those with least wilt were those which were furthest removed from the zones of heavy infection.

TABLE I.

Percentage wilt on plots.

(Thick black type indicates plots included in areas planted to sunn hemp in 1927-28.)

Manurial treatment.	Unlimed.			Limed.		
	A	B	C	A	B	C
Untreated	83.8	**97.2**	**95.2**	31.6	**98.9**	66.3
Pen manure	83.8	**91.9**	36.3	31.6	**100.0**	52.7
Potash	**98.9**	44.6	**77.9**	**98.9**	30.8	46.3
Potash+ Phosphate	**96.9**	**100.0**	72.9	44.4	50.6	88.0
Potash+Phosphate+Nitrogen	75.0	89.3	48.7	48.9	**97.4**	88.8
Phosphate + Nitrogen	91.5	90.2	**98.6**	**91.3**	81.5	**98.9**
Phosphate	**100.0**	60.8	77.3	**87.9**	68.5	70.1
Nitrogen	88.8	**66.7**	82.7	**98.8**	**89.7**	71.4

TABLE II.

Averages of the above figures in ordinary type.

Manurial treatment	United	Pen	K	K P K P N	P N	P	N
Average percentage wilt	60.6	51.1	40.6	63.8	70.1	87.7	69.2	84.3

The influence, therefore, must be that manurial treatment has no significant influence on the incidence of the disease.

From the figures in Table I, it appears that the occurrence of wilt was slightly less on the limed portion. Each portion, unlimed and limed, had been treated in the same fashion and from one of the charts it will be observed that the area which had borne sunn hemp in the previous year was the same in each case. The unlimed and limed plots may therefore be grouped into comparable pairs by selecting plots which were given the same treatment and were, as nearly as possible, similar in situation and relation to a former sunn hemp area. This action renders possible the application of statistical methods to the data.

Results.

Mean average percentage of wilt on the unlimed portion ... 81.2 per cent.
Mean average percentage of wilt on the limed portion ... 72.2 per cent.
Difference between the means... 9.0 per cent.
Standard error of the mean difference ... ... 5.6 per cent.

The difference of the means is only equal to 1.6 times the standard error of the mean difference and therefore the result is not significant, though there exists a degree of probability that liming has some effect in the reduction of wilt.

Table II gives the average percentage of wilt on the plots outside the former sunn hemp areas. It is permissible to take plots indiscriminately from the unlimed and limed portions and average them since the effect of lime is statistically insignificant. In view of the results obtained by Rast, Ferris, Neal and Rosen (*loc. cit.*) on cotton, it is noteworthy that the least incidence of wilt occurred on the plots to which potash only had been applied.

Outbreak of the disease.

The initial confinement of the disease to those areas which had previously been planted to sunn hemp and which had been attacked by wilt, must be attributed to heavy soil infection. Considering, however, the operations that the soil had undergone since the last sunn hemp crop, the extreme localization of the disease is difficult of explanation.

A reason for the early marked infection of plants in the plots along the north side may be found in the fact that in 1926-27 sunn hemp was grown on that part of the field immediately adjacent to the experimental area on the north side and this crop had been affected by the wilt-fungus. This necessitates the assumption that the fungus is capable both of living saprophytically in the soil for two years and of lateral spread.

Infection in the case of isolated parts of the experimental area may have been brought about in different ways.

1. It is evident that particles of soil from infected areas must have been distributed over the experimental plot by agricultural implements, boots and the feet of the labourers.

2. On plants grown last year which were attacked by wilt the fungus was allowed to fructify and a wide dissemination of the conidia must have occurred. A dissemination of spores would also take place this year, though only after the plants were well established. A few spores, too, may have been borne on the wind from diseased plants growing in other parts of the farm.

3. Infection by seed seems highly probable if the seed was selected from an infected crop, for the native methods of reaping and threshing render such contamination unavoidable.

Considering together the outbreak of the disease and the known data, it is obvious that the amount of wilt varies with the degree of infection in the soil. This observation is in agreement with that of Fahmy (*loc. cit.*) on cotton wilt.

Spread of the disease.

From the radial spread of wilt from the former sunn hemp areas and from the spread round isolated outbreaks, it seems probable that the disease may spread from one plant to another. A further support for this theory was an occasional feature of the spread on the ridges. The disease spread in linear fashion along a ridge; one plant died, then the adjacent one and so on until all the plants on the ridge had succumbed.

These observations, though they give indications of the spread of the disease, are not reliable for the location of the fungus in the soil was not known.

Plots, representative of each treatment, which were wholly included in former sunn hemp areas, were selected and the average percentage of wilt in these was calculated at the end of the 4th, 6th, 8th, 10th, 12th and 15th week. A graph was then made by plotting the percentage of wilt against the time. The same procedure was adopted in the case of representative plots which were as far removed as possible from the former sunn hemp areas.

From these two graphs the conclusion can be drawn that, following infection on the uncontaminated plots the spread of the disease, after a slight initial lag, was as rapid as in the case of the plots contaminated by the previous diseased crop of sunn hemp.

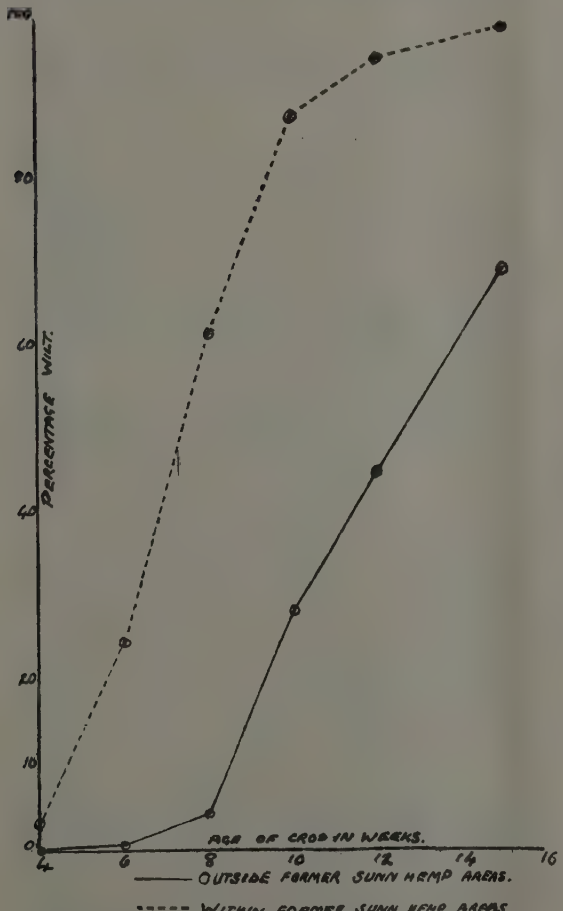

Fig. 2. Showing the difference in time of wilting within and outside the former sunn hemp areas.

Influence of Hydrogen—and Hydroxyl-ion Concentration on the growth of the fungus.

In the study of the effect of the hydrogen—and hydroxyl-ion concentration on the growth of the fungus it was found that the usual synthetic, nutrient substrates, on which fungi are grown, were useless for they were altered considerably in reaction on autoclaving. A commercial nutrient broth, designated as "Difco standardized" which showed no appreciable change, was selected. It consisted of:—

Bacto beef extract—3 parts,

Bacto peptone—5 parts,

and the medium was prepared by dissolving eight grammes of this preparation in 1000 ccs. of water.

The nutrient was divided up into ten quantities, each 100 ccs., and the reaction of each was adjusted by means of potassium hydroxide and lactic acid to obtain a range of pH 1.0 to pH 10.0 with intervals of pH 1.0. To perform the experiment in duplicate each 100 cc. quantity was divided in two and each portion poured into a flask. After sterilization each flask was inoculated with a small piece of mycelium.

Growth of the fungus was rapid in the flasks where the medium had a pH value of 6.0 and 7.0. No growth took place in the flasks where the pH value of the medium was 1.0, 2.0 or 10.0.

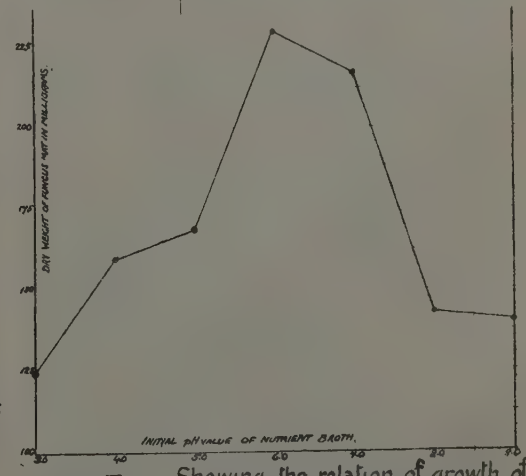

Fig. 3. Showing the relation of growth of sunn hemp Fusarium to H— and OH-ion concentration.

After 14 days the fungus mats were collected on dry filter papers and the pH value of the filtrates were determined. The filter papers with the fungus mats were dried for two days in a drying oven at 60°C. and then for one day in a calcium chloride desiccator. After weighing, the dry weight of the fungus mat in each case was obtained by subtraction. The data procured is shown in Table III.

TABLE III.

Growth of sunn hemp Fusarium in nutrient solution.*

Initial pH.	pH. after 14 days.	Dry wt. of fungus. mat in milligrams
3.0	3.4	124.9
4.0	4.4	159.9
5.0	5.2	168.7
6.0	7.8	230.6
7.0	7.8	217.5
8.0	7.8	143.0
9.0	8.6	141.0

As indicated by the dry weight of the fungus mat, growth was greatest when the initial pH was 6.0 and it was only slightly less at pH 7.0. The growth curve between the limits pH 3.0 and pH 9.0 was fairly regular as is shown in fig. 3.

Where the substrate was initially acid the acidity was reduced by the growth of the fungus and in the case of cultures started at pH 6.0 the medium was rendered alkaline. This also occurred when the pH was initially 7.0. Alkaline solutions were reduced in alkalinity.

Infective powers of Macroconidia.

The following experiment was performed to determine the infective property of the macroconidia, which are produced on the exterior of diseased plants.

Seed was sown in six kerosene tins which were filled with soil from a part of the farm, well isolated from any sunn hemp crop. When the seedlings appeared through the soil they were thinned out to leave three seedlings in each tin. Precautions were taken to ensure no root damage of the remaining plants by breaking across instead of uprooting those in close proximity.

When the plants were a month old the soil in three of the tins was infected by the addition of the freshly formed spores of the fungus. This was done by making a spore suspension in water and applying it to the soil round the bases of the plants. There was the risk of introducing mycelium but care was taken to remove no more material from the exterior of the diseased plant than would be possible by wind.

The first plant wilted 23 days after inoculation of the soil and by the end of three and a half months, when the experiment was terminated, eight of the nine plants had succumbed to wilt. The remaining plant was examined but showed no signs of the disease. The sunn hemp Fusarium was isolated from the diseased plants.

*Average of two cultures.

In one of the control tins two plants died of wilt but no precautions had been taken to sterilize the seed or the soil and infection by wind borne spores was possible. The seven remaining control plants were quite healthy at the cessation of the experiment.

	No. of plants.	*No. of plants wilted.*
Inoculated	9	8
Control	9	2

There is sufficient evidence to show that newly formed macroconidia are capable of causing infection.

Viability of Macroconidia.

Considering the infinite number of spores produced on diseased plants and disseminated by wind, the logical conclusion is that it would be impossible to grow sunn hemp anywhere in the vicinity of a previous diseased crop. This, however, is not the case. Observations were conducted on the viability of the spores. In all cases the germination was tested in "hanging drop" cultures in tap water.

Newly produced spores were found to give nearly 100 per cent. germination. After a few weeks in the laboratory this was reduced to about two per cent. and a few hours exposure to sunlight was sufficient to destroy the viability of the spores completely.

Infection by Seed.

The seed examined was from the remaining plants on the experimental area. A considerable quantity of foreign matter, particles of stems, leaves, pods and soil, was found in all the selected samples and it was thought that it would be an easy matter to prove the presence of the fungus. Several attempts were made and different Fusaria isolated but in no case was the sunn hemp Fusarium obtained.

A further test for infection by seed was carried out. Sterilized seed was sown in sterilized soil, contained in four kerosene tins. Unsterilized seed was washed in sterile water and the washings applied to the soil in three of the tins. This operation was repeated several times in an endeavour to infect the soil. The fourth tin was used as a control. The experiment was terminated after 50 days and no infection was obtained. The plants were uprooted and examined and no indication of disease was observed.

The seed was tested two months after threshing and it is probable that the inability to isolate the fungus or to produce infection was due to the short period of viability of the spores.

Cause of Wilting.

As regards wilt diseases in general the opinion is that the production of toxin by the fungus has a greater influence in bringing about the wilted state of the plants than has the partial plugging of vessels by wound gum and hyphae of the fungus. Rosen (*loc. cit.*), as already stated, attributes wilt in cotton to the production of nitrite from nitrate by the action of the fungus. He found, too, that cotton seed was unable to germinate in the presence of nitrate together

with fungus inoculum. The following experiments were carried out to determine whether the same things were applicable to sunn hemp wilt.

Experiment I.

The effects of nitrate; nitrite and nitrate with fungus inoculum were tested on the germination of the seed. Filter papers were moistened with one per cent. solutions of the nitrates of sodium and potassium and with 0.8 per cent. solutions of the nitrites. One filter paper moistened with sodium nitrate solution was heavily smeared with the mycelium of the fungus. Sterilized seed was spread out to germinate on these papers and the different germinations observed. The results obtained are tabulated as follows :—

Solution used to moisten filter paper.	*Number of seeds.*	*Number of seeds germinating.*
1. Sodium nitrate	20	17
2. Sodium nitrate+fungus	20	16
3. Potassium nitrate	20	16
4. Sodium nitrite	20	0
5. Potassium nitrite	20	0

The sunn hemp Fusarium together with nitrate has no inhibitory action on the germination of the seed but this property is possessed by nitrite.

Experiment II.

Rosen (*loc. cit.*) states that nitrite is produced by the action of the cotton wilt fungus in the presence of inorganic nitrogen, but not in the presence of organic nitrogen. A test for similar properties was conducted on the sunn hemp Fusarium. The following solution was prepared :—

Calcium sulphate	0.84 grammes.
Magnesium sulphate ..	0.25 do.
Potassium dihydrogen phosphate	0.25 do.
Ferric chloride	trace
Water	1,000 ccs.

To half of this solution was added inorganic nitrogen as 0.65 gms. of sodium nitrate and to the other half organic nitrogen as 0.5 gms. of sodium asparaginate. 2.0 per cent. of glucose was also added in each case. The fungus was grown on each portion and the presence of nitrite was tested for at the end of 2, 14 and 28 days by means of Safranin-T and hydrochloric acid. In no case was the presence of nitrite detected.

Experiment III.

After 14 days growth on these media, the fungus mats were filtered off and the filtrates were diluted with twice their volume of water. The original solution containing nitrate was also similarly diluted. In this experiment the solution with sodium asparaginate was not used as it was found to be unable to support the growth of seedlings. These solutions were placed in jars and in each case the stems of six sunn hemp plants were cut across under the surface of the liquid. The same thing was done under the surface of water containing a trace of sodium nitrite.

The nitrite produced rapid wilting and after 48 hours the plants in the filtrates and in the original solution were still turgid.

It would seem, therefore, that the fungus filtrates had no toxic effect on the plants.

Place of Infection.

Thirty sterilized seeds were germinated and the primary roots of 20 were inoculated with a small piece of mycelium of the fungus. The ten uninoculated seedlings were placed in one jar and the inoculated seedlings in two other jars which contained Knop's nutrient solution. This has the following composition :—

Calcium nitrate	1.00 grammes
Magnesium sulphate... ...	0.25 do.
Potassium dihydrogen phosphate	0.25 do.
Potassium nitrate	0.25 do.
Ferric chloride	trace
Water	1000 ccs.

The experiment was continued for 14 days during which time five of the seedlings which had been inoculated were broken. On examination of the seedlings at the end of the period it was found that (1) the uninoculated seedlings were all healthy, (2) of the inoculated seedlings two were healthy, eight had developed lesions at the collar region and the root tips of the remaining five had been killed.

These observations are in accordance with those made in the field.

Time of Infection.

As previously stated the crop on the Experimental Area was a month old before any plants wilted. To confirm this observation two other sowings were made and careful examination made regularly for the first appearance of the disease.

The following are the results of the three sowings :—

Date of sowing.	*Date of first appearance of wilt.*	*Age of crop.*
1. 24th Oct.	24th Nov.	31 days
2. 12th Dec.	10th Jan.	29 days
3. 16th April*	15th May	29 days

To test whether the fungus was capable of penetrating the plant during the initial stages of development and also whether the plant was capable of further development after attack had taken place, the following experiments were performed.

Experiment I.

Sterilized seed was germinated on moist filter papers. After 48 hours the primary root tips were inoculated with the spores of the fungus. Another 48 hours were allowed to elapse and then the roots were fixed, microtomed and stained.

It was found on microscopical examination that, in all cases, the fungus had penetrated a considerable distance into the tissues and in some instances had killed off several cells.

Experiment II.

Seeds were germinated as previously and six were inoculated at the root tip with the spores of the sunn hemp Fusarium and six with the spores of a species of Penicillium. A similar period of 48 hours was allowed for penetration and then the germinating seeds were fixed in test tubes containing water and the seedlings allowed to develop. Six uninoculated seeds were used as controls.

The root tips of those seedlings which had been inoculated with the sunn hemp fungus died but adventitious roots were produced and the plants developed equally as well as the others.

In the course of the experiment one control seedling and two inoculated with the Fusarium were broken. Of the remaining seedlings inoculated with

* This crop had to be watered regularly because of existing drought.

the Fusarium, the first plant wilted 20 days after inoculation and by the 32nd day all four had died. As in the field the pink sporodochia of the fungus were produced on the exterior of the diseased plants. At the conclusion of the experiment all the controls and the seedlings inoculated with the Penicillium were still alive.

Experiment III.

The last experiment was extended. The root tips of germinating seeds were heavily inoculated with mycelium instead of spores and in addition to the sunn hemp fungus and the Penicillium a saprophytic Fusarium was included in the inoculations.

Fungus used to inoculate.	*Number of seeds.*
Sunn hemp Fusarium	12
Saprophytic Fusarium	6
Penicillium	6
Uninoculated controls	12

After allowing 48 hours for penetration by the fungus the germinating seeds were placed in 250 ccs. flasks containing Knop's nutrient medium, two seeds in each flask.

Strong growing seedlings were produced in every case, despite the fact that the root tips of all those inoculated with the sunn hemp fungus were killed. As in the previous experiment, adventitious roots were formed in the region beyond he dead area. Wilting and death of these seedlings ensued but only after a period of active growth. Appended below is a record of the ages of the plants at which wilting occurred.

Number of plants wilting.	*Age.*
4	16 days.
1	17 days.
1	22 days.
2	25 days.
2	28 days.
1	32 days.
1	34 days.

All the controls and those seedlings which had been inoculated with the saprophytic Fusarium and with Penicillium remained healthy.

Summary.

1. The Wilt disease of *Crotalaria juncea* is caused by a species of Fusarium, which is probably a biologic strain of *Fusarium vasinfectum*.

2. The fungus lives saprophytically in the soil and may attack a plant *via* the tap root, a lateral root or the collar region.

3. The intensity of the disease varies with the degree of infection of the soil.

4. The pink sporodochia of the fungus are formed on the exterior of the stems of diseased plants and the spores produced are capable of infecting a growing crop. The spores lose their vitality on exposure to sunshine for a few hours.

5. In the field the crop is a month old before the disease appears. Laboratory experiments show that the fungus may penetrate the germinating seed and the seedlings grow normally for some time. The shortest period from the time of infection to the appearance of Wilt was 16 days, the longest 34 days and the average 24 days.

6. The water content of the soil is without influence on the disease.

7. Manurial treatment does not affect the incidence of Wilt.

8. The application of lime to the soil produces no statistical difference in the extent of the disease but there is a strong probability that liming is beneficial.

9. The disease is spread by spores and infected soil. The short period of viability of the spores renders infection by seed improbable.

10. Disinfection of seed for Colletotrichum would also be efficacious for any viable Fusarium spores. Immersion of seed in 1-1,000 mercuric chloride does not affect germination.

11. The fungus does not grow in media with a pH value less than 3.0 or greater than 9.0. Maximum growth takes place in media with an initial pH of 6.0.

12. Seed germinates normally in the presence of nitrate with fungus inoculum. The presence of a trace of nitrite inhibits germination.

13. The action of the fungus does not effect the reduction of nitrate to nitrite.

14. On artificial media the fungus does not produce substances which are toxic to the plants. It seems probable that the wilted condition is brought about by the actual blocking of the vessels of the plant by fungus mycelium and wound gum.

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FERTILISERS IN SOUTH INDIA.

Record of Progress.

[Compiled from a Report received through the courtesy of Imperial Chemical Industries, Limited.]

THE maintenance of an adequate supply of organic manures is a very important problem in India where there has always been a particular shortage of these manures. The Madras Department of Agriculture has devoted many years to the study of this problem and has shown that fertilisers can be used advantageously in combination with organic manures. For instance, in many localities sulphate of ammonia and superphosphate are used successfully to supplement farmyard manure, the latter being reduced to half its usual quantity. Moreover, sulphate of ammonia has been applied with good results as a top dressing to paddy nurseries situated in districts where soils are light and where the late rains make it necessary to force the seedlings. The efforts of the Department have primarily been directed to the paddy crop, but increasing attention is now also being paid to the use of artificial manures on other crops. When the need for fertilisers had been definitely established, means had to be found to secure necessary supplies. In this connection Imperial Chemical Industries, Ltd., have more recently, started an organisation whereby depôts have been created all over the countryside at which the ryots can obtain fertilisers easily and cheaply, in packets suitable for their needs and understanding. This organisation is administered by a staff which is working in close co-operation with that of the Agricultural Department, and during the last five years great strides have been made in the popularisation and distribution of fertilisers. The results so far achieved have been most satisfactory and indeed very successful when consideration is taken of the difficulty of spreading knowledge amongst a population which is not only ignorant but scattered in numberless villages.

The Madras Presidency is divided arbitrarily by the Agricultural Department, for purposes of their administration, into eight districts or circles, each of which is in charge of a senior agricultural officer with his own field staff. The following table shows the quantities of fertilisers which were sold in the various districts by Imperial Chemical Industries, Ltd. during 1929 to 1930.

Districts or Circles.	Sulphate of Ammonia.	Superphosphate.	Ammophos.	Leunaphos.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1st Circle (*a*) Vizagapatam ..	189	45	—	—
	(1928-29) 19	(1928-29) 18	—	—
2nd Circle (*b*) Guntar	20,000 bags	—	Limited sales.	Limited sales.
3rd Circle (*c*) Bellary	185	260	200	19
5th Circle (*d*) Trichinopoly ..	879	388	649	—
6th Circle (*e*) Madura	1,153	411	106	14
7th Circle (*f*) West Coast ..	31	43	16	—
8th Circle (*g*) Coimbatore and Salem.	273	33		—

District Notes.

(*a*) Sales of fertilisers have progressed rapidly during the past few years. Groundnut cake is more easily obtainable than in some other localities, but as the unit price of nitrogen in sulphate of ammonia remained below that in groundnut cake it has been used as a supplement for cake over large areas. At the Anakapalli Government Station the effects of groundnut cake and sulphate of ammonia used with a basal dressing of farmyard manure are being compared. At Samalkota, sulphate of ammonia is being compared with groundnut poonac as a manure for sugar-cane. The results show that provided the soil is well supplied with phosphoric acid, 525 lb. of sulphate of ammonia is a satisfactory substitute for 1,640 lb. of cake. At present prices there is little difference in the cost of the two manurial systems, sulphate of ammonia being, if anything, a little cheaper. Comparisons are also being effected in the uses of sulphate of ammonia, green leaf, and a combination of the two.

(*b*) A large area of dry land cultivation where the effects of artificials have not as yet been studied.

(*c*) In the wetter tracts fertilisers are gaining ground rapidly for application to paddy and sugar-cane.

(*d*) Sulphate of ammonia is a popular manure, partly because of the large area of delta paddy and partly because of the number of agricultural co-operative societies which have been persuaded to demonstrate its benefits on their own farms. These societies have sold large quantities of fertilisers to their members.

The shortage of organic manure is very great. Large areas of paddy prohibit the preparation of farmyard manure, and green dressings are difficult to raise, as much of the land is double-cropped. Despite activities to encourage the ryots to conserve organic matter in every possible way, the supply is not sufficient for more than a quarter of the total arable area. The value of artificials applied to the cereal crop which precedes cotton in the usual rotation is being

tested. Results have shown the profitableness of using sulphate of ammonia and superphosphate in combination with farmyard manure.

(*e*) A great shortage of organic manures.

(*f*) Soils markedly deficient in lime, and perhaps not so well suited to the use of artificials. The use of sulphate of ammonia for paddy nurseries is an established practice round Tellicherry. It is applied also to sugar-cane, the second and third paddy crops, and to coconuts. Ammophos becoming popular for vegetables. Trials with nitro-chalk are promising.

(*g*) Mainly cotton growing areas. With the introduction of high yielding strains of paddy, the need for more intensive manuring has been emphasised, and actively demonstrated by the Department.

In the 4th Circle (Madras area), experiments are being conducted to discover the most economic application of groundnut cake and sulphate of ammonia, and of sulphate of ammonia, by itself, for sugar-cane. These fertilisers either in combination or by themselves have already proved beneficial in this locality. The object of the experiments (not yet completed) has been twofold, firstly, to prove that the fertilisers are beneficial and secondly, to ascertain the most economical dressing.

The above summary does not pretend to account for all the artificials sold in the Madras Presidency as the Agricultural Department is unable to keep track of all sales, nor does it attempt to do so. The past year also has been an unfavourable one. The Congress propaganda, and the general boycott of British goods have exerted their baneful influence, though perhaps to a lesser extent, on the fertiliser trade and upon Departmental work, as on other trades and social services.

G. G.

GERMINATION OF MAIZE.

Selection of Maize for Germination and other Tests.

Mr. R. C. Malhotra, of St. Mary's College, Kansas, states that in germination tests of maize seedlings he finds that the irregularly shaped seeds taken from the tip and butt ends of the ear, especially those in which the embryo is located at the side of the seed, seldom if ever germinate. The use of such seeds, even if of heavy weight, may cause an experimental error of 20-25 per cent. in germination. In the middle of some ears a number of compressed, thin, undeveloped, and starved seeds may be found. They germinate promptly, probably because of the thin pericarp, but produce poor, undernourished seedlings and should be excluded from germination experiments. In experiments with X-rays and ultra-violet light, the effect of exposure is very different according to which side of the seed is exposed, as the embryo is much nearer one side than the other. The embryo side should be exposed for uniform results. —(*Nature*, Vol. CXXVII, No. 3201.)

FERTILISER PRODUCTION.

Recent Developments in Fertiliser Production.

Two papers concerning the recent progress that has been made in the artificial fertiliser industry have been published from the Fertiliser and Fixed Nitrogen Investigations Laboratory at the Bureau of Chemistry and Soils, Washington, (*Industrial and Engineering Chemistry*, Vol. 23, p. 14). Research on the production of fertilisers has had three main objects, (1) to produce all types of fertiliser in forms readily available to the plant, (2) to produce compounds containing more than one active nutrient element and a minimum of inactive elements, whereby production, transport and distribution costs may be minimised, (3) to produce fertilisers in a good physical condition in order to improve their keeping properties and to facilitate distribution in the field. The attainment of these objects has been largely assisted by the production of large quantities of relatively cheap anhydrous ammonia from atmospheric nitrogen.

The production of phosphorus in a form readily available to the plant from insoluble phosphatic rock has proved to be a task of considerable difficulty. Two methods of attacking the problem have been followed. The first method consists of grinding the phosphatic rock to a high degree of fineness whereby it can be uniformly distributed in the soil, and at the same time present a maximum surface area to be attacked by dissolving agents in the soil. Improvements in grinding machinery have been instrumental in producing modern ground rock phosphate of which 85 per cent. will pass through a 300 mesh sieve. In 1920, if 55 per cent. of a sample passed through a 300 sieve it was considered good. A natural, finely divided phosphate has recently been placed on the market under the name of "colloidal phosphate." It contains 18 to 25 per cent. of phosphoric acid (P_2O_5) and 90 per cent. by weight of particles finer than 5 μ (one-twenty-thousandth part of a centimetre) in diameter. This material has not yet been tested to show whether it is more readily available to plants than ordinary ground rock phosphate.

The second method of attack has been to develop the production of superphosphate. Superphosphate contains soluble di-hydrogen calcium phosphate. The objection to this fertiliser is that it invariably contains free acid which may be harmful to an acid soil. Attempts to reduce this acidity have been made by neutralizing the free acid with ammonia. The product is called "Ammoniated Superphosphate." About per cent. of ammonia can be added to ordinary superphosphate. Further addition of ammonia causes the precipitation of insoluble tri-calcium phosphate. The manufacturers hope to show, however, that this precipitated phosphate, being in a very finely divided form, is readily available to the plant. It has been shown that ammoniated superphosphate behaves peculiarly under chemical treatment and that the official method of analysis used for ordinary superphosphate does not give a reliable index of its relative availability.

A second type of soluble phosphate prepared directly from rock phosphate is known as "Triple Superphosphate". It is produced by substituting phosphoric acid for sulphuric acid in the process for obtaining superphosphate. By this method a material containing 40 to 45 per cent. of available phosphate can be obtained. One process uses the dilute phosphoric acid produced in the sulphuric acid method to act on fresh rock phosphate. By heating, the phosphoric acid is concentrated and the reaction promoted in a continuous operation and a dry product of triple superphosphate is obtained.

The most important advance in the production of phosphatic fertilisers has been the manufacture of phosphoric acid from phosphate rock by furnace methods. The electric furnace has been the chief factor in developing this method, although fuel furnaces have produced some satisfactory results. In the process, elemental phosphorus is produced first and is immediately oxidized to phosphoric acid. The phosphoric acid may then be combined with ammonia or potash as desired.

Ammonium phosphates containing both soluble nitrogen and soluble phosphorus with a minimum amount of waste material have gained considerable popularity. Ammonium dihydrogen phosphate is made by the treatment of rock phosphate with a mixture of sulphuric acid and ammonium sulphate. The calcium sulphate which is precipitated during the reaction is filtered off from the impure solution of ammonium phosphate which is formed. The impurities in the solution are chiefly iron and aluminium and are precipitated by addition of ammonia and are separated. The purified solution is concentrated until mono-ammonium phosphate or a mixture of this salt and ammonium sulphate crystallises out. The calcium sulphate sludge is treated with ammonia and carbon dioxide when calcium carbonate is precipitated and ammonium sulphate is formed in solution. The ammonium sulphate is re-used in the process and the finely divided calcium carbonate is used for the preparation of "Nitro-chalk."

Potassium and nitrogen are combined in an available form in potassium nitrate. The old method for the manufacture of potassium nitrate involved the double decomposition in solution of Chile sodium nitrate and potassium chloride. The sodium nitrate has now been replaced by nitric acid formed by the catalytic oxidation of ammonia. The excess nitric acid remaining in the mother liquor after the potassium nitrate has been crystallised out is reduced with ferrous chloride. The nitric oxide which is formed is expelled from solution by the direct action of steam and is used again. The resulting ferric chloride is reduced to ferrous chloride with iron filings and is re-used. In a more recent process solid potassium chloride is treated in a tower with gaseous nitrogen peroxide. Potassium nitrate and gaseous nitrosyl chloride are formed. The latter is reconverted to nitrogen peroxide by catalytic action. The economy of the process is in the absence of solutions which have high corrosive power on apparatus and require large quantities of heat for concentration.

Ammonium nitrate which can be made entirely from synthetic ammonia has many claims as a cheap nitrogenous fertiliser. Its use is limited by its hygroscopic nature. Under ordinary atmospheric conditions, it rapidly becomes too moist for transport and cakes too much for drilling. These difficulties have been overcome by mixing a hot concentrated solution of ammonium nitrate with precipitated calcium carbonate and spraying the mixture into a dehydrating chamber. The resultant product, known as "Nitro-chalk" or "Ammonium Nitrate-Limestone", is in a granular form, and is free from the disadvantages of ammonium nitrate.

Complete fertilisers are being made by processes which do not involve the separate preparation of any one of the components of the mixture. For example, phosphate rock may be decomposed with a mixture of potassium sulphate and nitric acid in suitable proportions. A precipitate of calcium sulphate and a solution of potassium nitrate and phosphoric acid are formed. Ammonia is used to neutralise the filtered solution. Concentration and spray drying gives a granular substance containing three molecules of potassium nitrate to one molecule of mono-ammonium phosphate. The advantages of such a method of preparation are that there is a minimum of inactive material present, that the mixture is homogeneous and that there can be no tendency for the individual compounds to segregate.

A granular condition appears to be the most suitable physical state for fertilisers. Granulation may be obtained by spraying the fused or moistened substance into a dehydrating chamber, or by allowing it to fall in a dispersed condition in a drying tower, or by the use of rotary driers. With granulation the tendency of the fertiliser to cake or become sticky is reduced. With fertilisers formed of mixed salts of different specific gravity the tendency of similar crystals to segregate is obviated. The ease of drilling is increased, affording greater control and accuracy. Uniform distribution and accurate placing of the fertiliser is obtained and its efficiency is thereby increased.

Now that the problem of obtaining supplies of available nitrogen has been solved, research is being directed to the recovery of phosphorus and potash from minerals containing relatively small amounts of these substances. Some success has already been obtained. Low grade phosphatic rock has been concentrated by a flotation method. The fact that both the elements are volatile has been used successfully in recovering them from other mineral sources. The supply of artificial fertilisers and consequently the world's food supply appears assured, therefore, for many centuries to come.

H. H. C.

A NEW COFFEE PULPER.

By A. N. Ritchie,
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During the 1930 coffee crop, a new type of coffee pulper has been on trial at the Mweka Plantation, Kilimanjaro, Tanganyika Territory (Manager: Mr. D. Meimarides) and upwards of one hundred tons of bean have been experimentally treated in the new machine. It has been freely admitted even by pulper manufacturers that the existing types of machine left much to be desired. Manufacturers have for some years now rung changes and made minor improvements on the disc and drum pulpers. The fermentation cum washing or wet process following pulping has also come to be looked upon as hardly ever likely to be dissociable from the manufacture of good coffee. The new pulper the "Roeang", manufactured by Messrs. Krupp of Magdeburg, Germany, is as to its mechanics and its process, original, if not revolutionary.

The pulper resembles in form a coffee huller or sheller. The pulley taking a five-inch belt, is at the left of the machine as are also the cherry receiver (in form as a huller receiver) and the parchment exit to the right of the machine. The main cylindrical housing of the pulper is approximately four feet in length. The essential parts of the pulper are (1) the outer housing of sheet steel next (2) the slatted or rectangularly perforated secondary drum or sheet steel and innermost (3) the rotating metal cylinder. The perforations in (2) are in circumferential width not greater than the thickness of the smallest of the coffee parchment handled. On the cylinder (3) there is a succession of circular metal ridges which when the machine is in action come in close juxtaposition to the part (2). There is also a series of longitudinal ridges which rise from the general drum surface immediately forward of each circular ridge up to the height of the next circular ridge being, therefore when looked at side on, wedge shape or a right angled triangle.

In each rectangular space (about 4 inches by 4 inches) formed by the intersections of the circular and the longitudinal ridging there is one water jet hole. The ridging to the extreme right of (3) is designed to direct the parchment to the exit point, the rate of delivery of parchment being controlled by a lid under weighted control. Immediately below the cherry receiver, on (3) there is a spiral ridging much like that on a domestic mincing machine directing the cherry forward. The water feed (2½ inch pipe) enters the cylinder (3) on the right. The water requirements of the pulper are rated at about eight cubic metres per hour's pulping—an amount comparatively with old method pulpers not considered inordinately high. 15 h.p. is required for the running of the pulper, the shafting working at 400 revolutions per minute. In process, the cherry is propelled into the pulper by the initial spiral and is pulped by the revolving ridging against the grating—the devilled or beaten pulp being washed out through the perforations in (2) by the strong force of water jetted from the holes in the cylinder (3) and passing down with the surplus water below the pulper. The parchment is propelled from left to right and by attrition and scouring arrives at the parchment exit ready for transference to the grading channel and thence to the drying floor or mechanical drier (most factories prefer a preliminary natural drying prior to placing the parchment in the rotary mechanical drier).

It should particularly be observed that fermentation no longer forms part of the preparation process. The dried new method parchment is indistinguishable from that of the old method. Both London and Hamburg have reported—upon parcels of new and old method 1930 Mweka crop—that the appearance of bean treated by the new method is preferable to that of bean treated by the old fermentation method. In the Mweka trials, the machine showed a possible average performance of 300 debes (paraffin tins) of 12 kgms. cherry per hour. In the 1930 Mweka crop the ratio of cherry to parchment was as low at times as 4.7 to 1 although an average is between five and six to one.

Recent work in Kenya has been directed to studies of the biology and chemistry of the fermentation process with a view to its expedition. With the present pulper, we have the advent of a more direct coffee process.

TSETSE FLY CONTROL.

Mr. C. F. M. Swynnerton, Director of Tsetse Research, summarizes the work at Shinyanga (Tanganyika) as follows: "The decision to take a fly-belt, and, in co-operation with the Administration, try what we could do against it with the knowledge at our disposal—this to be reinforced by suggestions gained from research—has been justified by the practical results. Annual clearings are now being made by the tribe itself as a *custom*; passages are being broken through into great natural open spaces; the organised grass-fires have brought further result without appreciable destruction of wooding or game; natives and cattle are entering in numbers to seize on our gains; a township has been built on the ground and trees are being planted by thousands where five years ago our one need was to get rid of them. Much practical knowledge has been acquired and the fly-belt, in course of being broken into blocks for piecemeal treatment, stands ready for further experiment.

"Research has hardly yet come into the picture, but as the direct result of the interest aroused by Shinyanga, a research team has come into being, and its earliest discoveries—that of the 'feeding-grounds' (Jackson), and that of the fly's dependence on eyesight for hunting (Nash)—are being used."

Further highly important experimental work is being carried out.—(*The Empire Cotton Growing Review*. Vol. VIII, No. 1.)

REVIEWS.

The Culture of the Orange and Allied Fruits.

By H. Clark Powell. *The Central News Agency*, S. Africa. Price £1 1s.

In this book, an attempt has been made to produce in a single volume a fairly complete, general guide to the commercial cultivation of the different species of Citrus fruit. It is comprehensive in character and describes the correct methods of growth from the establishment of the seed-bed to the final marketing of the crop. It deals primarily with Citrus production in South Africa, but much of the subject matter is of general application; especially is this so, in the chapters on the Nursery, Varieties, Tree Records, Packing and Marketing. A brief but interesting account is also given of the present position and importance of the main Citrus-growing countries of the world, and the problems to be met with in each. Certain sections appear to be somewhat outside the scope of the work, *e.g.*, the description of field experiments and statistical analyses.

The author has refrained from making the book too technical in character, so that it ought to be particularly useful to the grower and to the student. It is to be commended for the care with which the practical details of cultivation are described. Necessarily with a volume of this character, where a great deal of information has been confined in a small space, the paragraphs tend to be short and somewhat disconnected, and the text is rather too much in the form of a catalogue of facts.

Numerous plates have been included and these add greatly to the interest. A full and useful bibliography has been appended which should be helpful to the reader who requires greater details on any particular problem.

D. D. P.

* * *

The Physical Properties of the Soil.

By Bernard A. Keen, *Longmans, Green & Co., Ltd.*, London, 1931, Price 21s. (Rothamsted Monographs on Agricultural Science.)

The two main objects of this welcome book are firstly to give an account of the results of recent investigations on the physical properties of soil in a form easily available to agricultural research workers, teachers and students; secondly, to indicate to trained physicists the enormous scope for the application of precise physical methods to the elucidation of problems presented by soil in the various aspects of its behaviour, both in the laboratory and in the field.

The investigations mainly described were conducted under the author's direction at the Rothamsted Experimental Station, England. In this respect, the book therefore claims to be neither an exhaustive treatise on Soil Physics, nor a historic documentation of the development of the subject during the last 20 years. In the introduction, Dr. Keen stresses the facts that knowledge of the physical properties of soil is important because it leads to the development of a scientific basis for cultivation operations, and because it furnishes information concerning the environmental conditions to which green plants, as well as soil-inhabiting micro-organisms, are subjected.

The book is divided into ten chapters, which respectively discuss the history of the subject, mechanical soil analysis, water movement in soil, the properties of relatively dry soil, the behaviour of soil pastes and water suspensions, physical soil constants, the behaviour of soil when cultivated in the field, soil temperature and the soil atmosphere. A good index to authors (mainly past and present workers at Rothamsted), and to the subject matter, together with numerous diagrams and graphs, concludes the volume in 380 pages.

To the beginner and to students of general agriculture, the book will undoubtedly prove stiff reading. Its study presupposes a thorough knowledge of pure physics and mathematics. Its value and usefulness will be chiefly appreciated by research workers belonging to those institutes in which soils are studied in their widest aspects, and where freedom of choice of problems for detailed and fundamental study is allowed. At the same time, the book should convincingly indicate to the agriculturist the great complexity of the soil system, and the enormous difficulties that beset investigators who attempt to unravel its relationships, and to explain its behaviour in the field.

F. H.

COLLEGE MEMOIRS.

The following can be obtained on application to the Editor:

Economic Series:

No. 1.—The Sugar Industry of the British West Indies and British Guiana, with special reference to Trinidad ..	.. C. Y. Shephard	1s.

* * *

Sugar Technology Series:

No. 1.—Cane Syrup ..	R. H. Hurst	1s.
No. 2.—Experiments with Final Molasses ..	J. A. McDonald	6d.
No. 3.—Sampling of Cane in the Field	J. G. Davies	6d.

* * *

Mycological Series:

No. 1.—Collar and Stem Canker of Pigeon Pea ..	R. Leach and J. Wright	6d.
No. 2.—Control of the American Leaf Disease on Arabian Coffee in Trinidad ..	H. R. Briton-Jones	1s.
No. 3.—Observations on Cypre in Trinidad ..	H. R. Briton-Jones and R. C. Marshall	8d.

TROPICAL WORLD NOTES.

East Africa.

The Department of Overseas Trade's latest Report on East Africa states that Uganda's 1930 cotton crop reached only 125,000 bales owing to critical weather conditions, the crop yielding something in the neighbourhood of £1,300,000 to the native growers, a reduction of some 60 per cent. from the preceding season. The Cotton Buying Association was dissolved as apparently the native did not favour it, believing that it would result in restriction of prices. The situation created thus permits of the reinstitution of uneconomic competition in seed cotton buying by the ginning industry, but a change may eventually result in that the low prices foreshadowed for the next crop may educate the native grower to change his opinion that combination necessarily means low prices and may result in a resurrection of the Cotton Buying Association, or Associations, which the Government favours but will take no steps officially to enforce.

The yield of coffee from European estates in Kenya in the crop year 1929-30 was, roughly, 10,000 tons and, following improved weather conditions and a comparative absence of pest troubles, it is estimated that some 12,500 tons of considerably improved quality will be produced during 1930-31 from the bearing proportion of the 95,265 acres registered as planted at present. The outstanding feature of the period under review has been the reduction in the average price from about £105 per ton to under £70, although it has recently recovered slightly. This fall has stimulated an attempt to reduce costs of production, and efforts are being made to get sea and rail freights and wages reduced. The proposed establishment of a coffee institute has resulted in a Bill being prepared by the Kenya Government based upon the principle of a pound for pound contribution from State funds, but in the present difficult financial circumstances it is unlikely that legislation will be promoted immediately. The question of natives growing coffee under strict supervision, as they do in Uganda and Tanganyika, is understood to be under consideration.

In Uganda approximate acreages under coffee are as follows :—

	Arabica.	*Robusta.*
European	12,968	5,328
Asiatic	762	667
Native	5,417	10,971

A new development is the growing of Arabic coffee by natives in the Toro district under strict Government supervision. Legislation is under consideration for the grading of coffee for export. In Tanganyika the total 1929 crop reached about 7,750 tons, of which, approximately, just over 6,500 came from the Bukoba district. For 1930 the corresponding estimates are Northern Province and Usambara 2,250, or an increase of about 10 per cent., and Bukoba 7,000 tons.

The reduction in the price of sisal to a figure under the best possible cost of production has affected cutting programmes somewhat in Kenya, although in Tanganyika the tendency seems more in the direction of increasing outputs to reduce unit overheads. Reduction of rail freights have been secured and attempts are being continued to obtain lower sea freights. A new decorticator designed in Kenya, for which a British firm holds the manufacturing rights, has created a considerable amount of interest because of its improved percentage extraction of fibre.

The Zanzibar clove crop, which at first view seemed to be in excess of consumptive power with a possible reaction of largely reduced prices was eventually taken up well at fully maintained values, purely owing to the opening of a new market, *i.e.*, the manufacture of cigarettes from cloves in the Dutch East Indies.

* * *

Sierra Leone.

The following table shows the quantities and values of the principal exports of Sierra Leone for 1930 and the previous year :—

	Exports—1930		Exports—1929	
	Quan.	Value	Quan.	Value
		£		£
Palm Kernels Tons	56,641	664,599	60,205	876,308
Palm Oil ..Tons	3,652	79,320	2,845	75,153
Piassava ..Tons	2,446	36,582	1,232	17,177
Ginger ..Cwts.	39,437	57,228	30,966	59,308
Kola ..Tons	1,634	126,251	3,128	266,422
Cocoa ..Tons	80	2,546	96	3,398
Pepper ..Tons	110	4,421	62	5,131
Rice ..Cwts.	2,342	1,324	260	220

It is seen that the exports of piassava led those of 1929 by 1,214 tons. The total of palm kernels for the year was less by 3,564 tons or 6 per cent. than in 1929. Considering that the price of these last year was £6 per ton less than in 1929, the difference in exports does not signify any likelihood of decreased activity of production. The ginger exports for 1930 hold a definite lead over those of 1929, although the value was considerably less.

* * *

The Gambia.

According to Colonial Report No. 1506 the production of groundnuts, which is the staple crop on which the prosperity of the Colony depends, fell considerably during 1929. The crop was much better than the previous year in quality but disappointing in quantity. The agricultural Department distributed 20,057 bags of seed groundnuts to the native farmers during the year under review, the total cost of which was repaid after the crop was harvested and sold. There were good crops of maize and millet and although rice is cultivated extensively, not enough is grown to satisfy local demand.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Reducing Production Costs.

A detailed cost study, by J. S. B. Pratt, Jr., of 22 Hawaiian plantations, averaged for four crops, reveals that the variations in the costs of these plantations are due to differences in accounting methods. On the basis of the figures obtained the author states that the quickest way to reduce unit costs is to increase production without increasing yearly operating costs. This has been and is being done by variety changes, increased use of fertilizer, short cropping, elimination of unproductive off-season, &c. The type of crop to raise is one that will show the largest profit per ton of sugar in the shortest time. On unirrigated Hawaiian plantations, plant cane may be the most profitable unless the yields of ratoon crops can be improved. When planting costs are high, a large area in ratoons is recommended.

A study of man-days per acre and tons of cane produced per man-day can be helpful in pointing out the less profitable fields; on one plantation there was a variation between fields of 400 per cent. in sugar per acre per month and 1,325 per cent. in tons of cane produced per man-day. Most places have not reached the stage of unprofitable fertilization and still have increased fertilization as an aid to lower costs through increased production. Large savings can be made by judicious buying and forecasting requirements.

The author mentions two intangible factors that would stimulate the Hawaiian sugar industry; more rapid promotion of men within companies and between them, and encouragement to visit other plantations, which would counteract the tendency to fall into a rut, as well as allow opportunity for observing different methods, varieties, labour saving devices, &c.—(*Facts About Sugar*, Vol. XXVI, No. 4.)

* * *

Factors influencing the Ash Content and Sugar Recovery.

During the 1929 season some factories in East Java produced molasses of a very high purity, notwithstanding their modern equipment, which should have led to a better result. Even after exhausting such molasses in the laboratory as far as could be done, purities remained high, which was traced to an abnormal composition of the non-sugars, especially in inorganic matter. This being a subject which has been little investigated, a systematic examination was made of the factors which throughout manufacture bear on the increase of ash. Firstly, as regards milling, Prinsen Geerligs has pointed out the effect of more intensive milling on increasing the ash; but in order to bring this influence up-to-date figures were obtained for two installations, each consisting of a crusher and four mills, the ash being determined in the different juices, and results calculated as the "ash per cent. non-sugars". This value was found to rise distinctly from crusher to fourth mill juice, though after all, this increase cannot be of much significance, when one considers the relatively small amount of juice which is expressed by the later mills. Secondly, as regards clarification samples of raw juice and syrup were collected from all the H.V.A. factories, filtered, and ashed. In the defecation factories the rise in the inorganic non-sugar was 9.14; and in the sulphitation factories 13.4 per cent.; but in carbonatation factories there was a fall, namely of 11.73 per cent. Going further into this, it was found that the ash concerned was mainly lime. Thus the CaO increase as the result of defecation was 132.2 per cent.; in sulphitation, 304 per cent.; but in carbonatation only 20 per cent. At the filter-presses of sulphitation and carbonatation factories, the ash re-entered the juice, as it was dissolved out during the washing of the cake; but the amount concerned, after all, considering the relatively small volume of the sweet waters, must be insignificant. During evaporation the ash per cent. non-sugars falls, due, of course, to scaling. Between evaporator syrups and molasses, there is a marked fall recorded, namely, 3.5 per cent. for defecation and 0.58 for sulphitation factories; but this cannot be due entirely to the small amount of ash removed by the sugars. A good part of it is apparently due to the Brix being determined by the one-tenth dilution method, this leading to a low result for the ash per cent. non-sugar.

However, while a greater or less amount of ash may be taken up during manufacture, the main factor is to be found in the conditions under which the cane is grown. Here, for example, are the ash factors since 1915:—

1915	1917	1918	1919	1920	1921	1922
18.4	18.9	19.3	19.7	19.9	19.7	19.5
1923	**1924**	**1925**	**1926**	**1927**	**1928**	**1930**
20.3	20.3	20.2	20.8	21.3	22.7	24.2

On plotting these values, a sudden rise is shown during 1926-29. Now this period coincides with the introduction and rise in the cultivation of P.O.J. 2878; and it would seem as though a high ash per cent. of the non-sugar were a property of the juice of that cane. During 1922-23, and 1925-26 there were also sudden jumps. Now it was during the years 1923-26 that the sugar yield per hectare was smaller than during the previous periods, traced as the result of abnormally small rainfalls. It would seem that dryness leads to a high ash content. Interesting results were also provided by studying the geographical situation of factories having unusual ash factors, and it was shown that in the molasses of factories in the more arid parts of Java the highest ash values are to be found.—(*International Sugar Journal*, Vol. XXXIII, No. 387.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.	*Preferential.*
	s. d.	*s. d.*
2nd April ..	6 7½	10 4½
9th April ..	6 6¾	10 4½
16th April ..	6 6	10 3
23rd April ..	6 4½	10 1½
30th April ..	6 3	10 0
7th May ..	6 0	9 9
14th May ..	6 3	10 0

The market which has remained steady since our last report, assumed an easier tendency towards the third week of April. The rapid progress made at the Conferences in Paris in connection with the Chadbourne Scheme culminated in final agreement amongst the countries represented. A settlement was also reached on the question of the basic price at which further quantities of sugar may be released for export over and above the quotas fixed in the general scheme. From a table published in *Messrs. Czarnikow's* report which shows the exports allowed under the Chadbourne Scheme it appears that the world has been relieved of upwards of three million tons of surplus sugars, and it may be assumed, by reason of the heavy reduction in invisible stocks, that withdrawals of sugar in future will bear a closer relation to actual consumption, whilst any moderate addition to invisibles would result in a more rapid correction of the statistical balance.

* * *

RUBBER—Quotations for Plantation Sheet have ranged as follows :—

	d.
1st April	$3\frac{5}{16}$
7th April	$3\frac{1}{4}$
14th April	$3\frac{5}{16}$
21st April	$2\frac{7}{8}$
28th April	$2\frac{13}{16}$
5th May	$3\frac{7}{8}$
12th May	$3\frac{1}{8}$

A new low record of $2\frac{13}{16}$d. was set up for May delivery. The market in the earlier part of April showed a tendency to decline and persistent rumours on restriction without anything being achieved in this direction, have not helped matters much. It is the belief of *Messrs. Symington and Sinclair* that large quantities of rubber are being produced, particularly by European owned companies, in the hope that restriction will be brought in sooner or later and thus save the situation for them.

* * *

COCOA.—In sympathy with other commodities at the present time the price of cocoa has reached a record low level and it is impossible for producers to carry on indefinitely at present prices. Statistically the position does not warrant such low prices but this factor apparently has no bearing on the situation as was usually the case in the past.—(*By courtesy of The Cocoa Planters' Association of Trinidad.*)

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :

	American Mid.	*Egyptian F. G. F. Sakel.*	*Sea Island.*		
			Good.	*Extra fine.*	*Prices paid this Week.*
27th Mar.	5·85	9·45	17·00	33·00	14·00
2nd Apr.	5·76	9·20	17·00	33·00	19·00
10th Apr.	5·59	9·00	17·00	33·00	—
17th Apr.	5·55	8·50	17·00	33·00	19·00-19·50
24th Apr.	5·62	—	17·00	33·00	—
1st May.	5·41	—	17·00	33·00	—
8th May	5·39	—	20·00	33·00	—
15th May (local)	5·62	—	17·00	33·00	—

The markets have been quiet with a declining tendency.

* * *

TEA AND COFFEE.—Tea prices, although they have remained low, have shown a tendency to rise. Recovery is due mainly to the greater prudence shown since January in consigning to London. The latest London averages include : Ceylon, 18.64d.; Indian, 13.88d. and Java, 7.26d. The demand for coffee of fine aroma and character is very fully supported and Jamaica, Costa Rica, and Colombia have only to tender high grade to meet with a prompt market. Total sales have, however, been disappointing.

* * *

BANANAS.—Jamaicas are in fairly good demand amd are a further £1 10s. od. per ton higher at £22 5s. od. delivered London and £22 nearest railway station; the price to retailers is about unchanged at one shilling per dozen. Brazilians are in good demand and unchanged at £18 per ton delivered nearest railway station.—(*West India Committee Circular*, 16th April.)

* * *

LIME PRODUCTS. *Lime Oil.*—Small sales of Handpressed have been made at 45 shillings. Distilled is very scarce at present; the spot value is 35 shillings, at which business has been done. *Lime Juice.* Concentrated is nominally unchanged at £8. Raw is unchanged at 1s. 6*d.* to three shillings per gallon according to quality. (*West India Committee Circular*, 16th April.)